Johnson Lane Area Drainage Master Plan

Executive Summary

July 2018

prepared for

Carson Water Subconservancy District | Douglas County

PROFESSIONAL ENGINEER - STATE OF NEVADA
RICHARD M. WASKOWSKY
Exp: 6/30/2020
CIVIL
No. 25084

Date Signed: July 2, 2018

MICHAEL J. KELLOGG
Professional Geologist (AZ, CA, UT)

Date Signed: July 2, 2018

JE FULLER
8400 S Kyrene Rd, STE 201
Tempe, AZ 85284
www.jefuller.com

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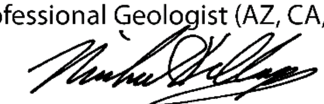

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1 INTRODUCTION

1.1 PROJECT PURPOSE

The Johnson Lane Area Drainage Master Plan (JLADMP) is encapsulated by three primary objectives: First – evaluate and identify flooding and sedimentation hazards within the Johnson Lane community by implementing a work plan that included data collection, review of previous studies, information gathering from public agencies and local residents, hydrologic and hydraulic modeling, geomorphic assessments, topographic mapping, and field surveys. Second – develop a series of alternatives to either partially or wholly mitigate the hazards identified in the first objective. Third – provide public outreach of the project through a series of public meetings to inform the public of the existing hazards and to present the mitigation alternatives.

Each major task of the project is presented herein with a description of the technical approach, analysis results, interpretation of results, and applicability to the overall project purpose. The results of this study can be used as a planning tool and as input to the design of potential future drainage infrastructure and flood mitigation measures that are appropriate for the physical environment for both existing and future development.

1.2 PROJECT LOCATION

The JLADMP study area is 27 square miles in size and is located on the eastern slopes above the Carson River Valley between Minden and Carson City. The entire study area is within unincorporated Douglas County and is bounded to the north by the Hot Springs Mountains, to the east by the Pine Nut Mountains, to the south by Sunrise Pass Wash, and to the west by Heybourne Road (Figure 1-1).

The unincorporated Johnson Lane community comprises approximately 12 square miles of private land located north of the Minden-Tahoe Airport and east of U.S. Highway 395. The community is bounded to the north and east by U.S. Bureau of Land Management (BLM) lands.

1.3 DATA COLLECTION

Voluminous data was collected and utilized for this ADMP and included the following:

- Previous Studies
- Drainage Reports
- Geologic Mapping
- NRCS Soils Mapping
- Aerial Photography (historical and modern)
- LiDAR mapping dated May 2017 flown specifically for the project

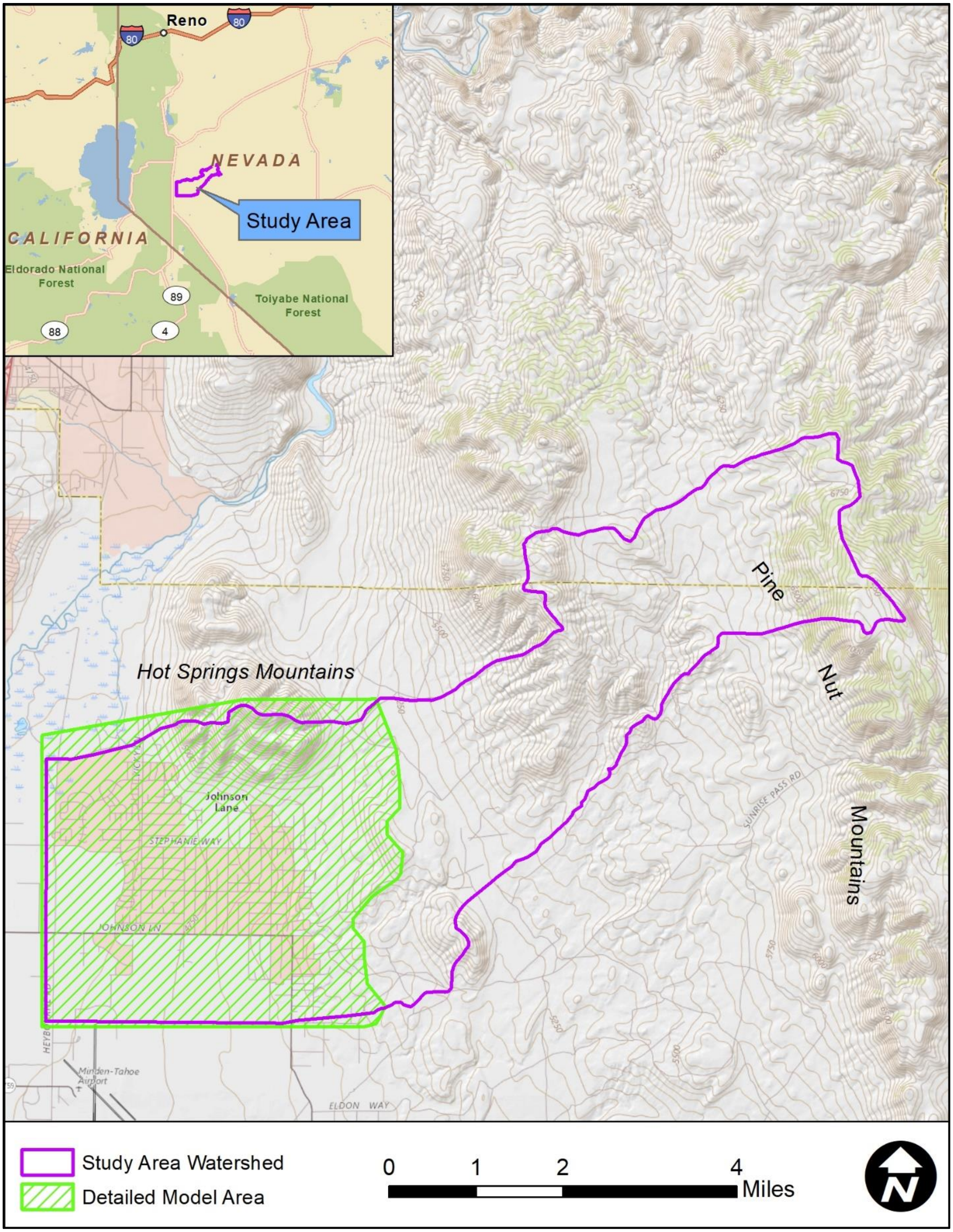

Figure 1-1. Study area vicinity map

2 WATERSHED SETTING

2.1 HYDROLOGIC SETTING

Flooding sources to the Johnson Lane community are the Hot Springs Mountains to the north and the Pine Nut Mountains to the east. Twelve watercourses that drain to the community were identified for analysis in this study (Figure 2-1). Table 2-1 lists each watercourse and its approximate drainage area upstream of the Johnson Lane community.

Table 2-1. Contributing watercourses to the Johnson Lane community

Watercourse	Source	Drainage Area (square miles)
Unnamed Wash A	Hot Springs Mountains	0.2
Southwest Wash	Hot Springs Mountains	0.2
South Central Wash	Hot Springs Mountains	0.4
Southeast Wash	Hot Springs Mountains	0.5
Buckbrush Wash	Hot Springs Mountains and Pine Nut Mountains	4.3
Romero Wash	Pine Nut Mountains	0.3
Stephanie Wash	Pine Nut Mountains	0.4
Chowbuck Wash	Pine Nut Mountains	0.3
Skyline Wash	Pine Nut Mountains	0.2
Johnson Lane Wash	Pine Nut Mountains	9.7
Unnamed Wash B	Pine Nut Mountains	0.4
Sunrise Pass Wash	Pine Nut Mountains	0.9
	Total	**17.8**

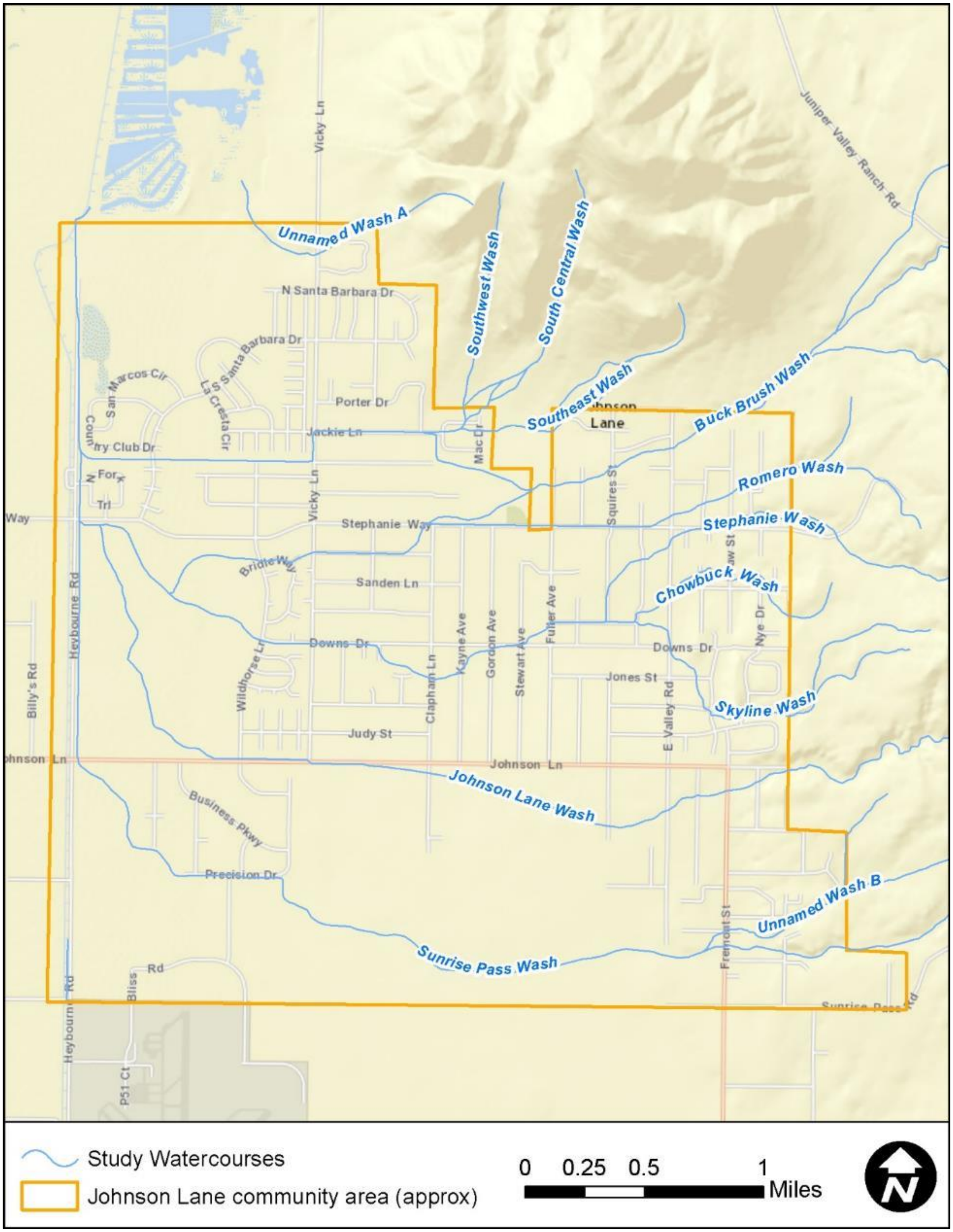

Figure 2-1. Study watercourses

2.2 Geologic Setting

The Johnson Lane community is built on a piedmont landform which is defined as the sloping surface at the base of a mountain or mountain range. Piedmont surfaces are frequently desired for development because of their shallow slopes and relative position above the adjacent valley river floodplain. Piedmont flooding hazards are unique from riverine flooding hazards and are often less understood and not properly addressed when designing community infrastructure. Much of the watersheds above the community are overlain with unconsolidated, fine to medium wind-blown sand which has been accumulating for at least the past 10,000 years. The sand is easily transported downstream from the mountain slopes during flood events. Changes in slope and/or obstructions in the path of the flood flows result in the deposition of the sand throughout the Johnson Lane community. The thick accumulation of sand on the mountain slopes provides a near endless supply that will impact the Johnson Lane area for the foreseeable future unless infrastructure is put in place to mitigate the issue.

2.3 Historical Flow Path Assessment

Understanding the historical evolution of a geomorphic system is critical to understanding present-day processes and predicting future trends. Natural systems can take hundreds of thousands of years to develop, and their morphology is a direct reflection of this long-development period. Anthropogenic modifications to a natural system often result in abrupt changes that can be managed for a brief period, but quite often the disturbed system will trend back to its natural condition, despite man's efforts to change and maintain it.

A historical flow path assessment was conducted for the JLADMP study area to assess the natural flowpaths of the study watercourses with the goal that understanding the natural flowpaths will aid in understanding the current flooding patterns and potential future flooding trends (Figure 2-2 and Figure 2-3).

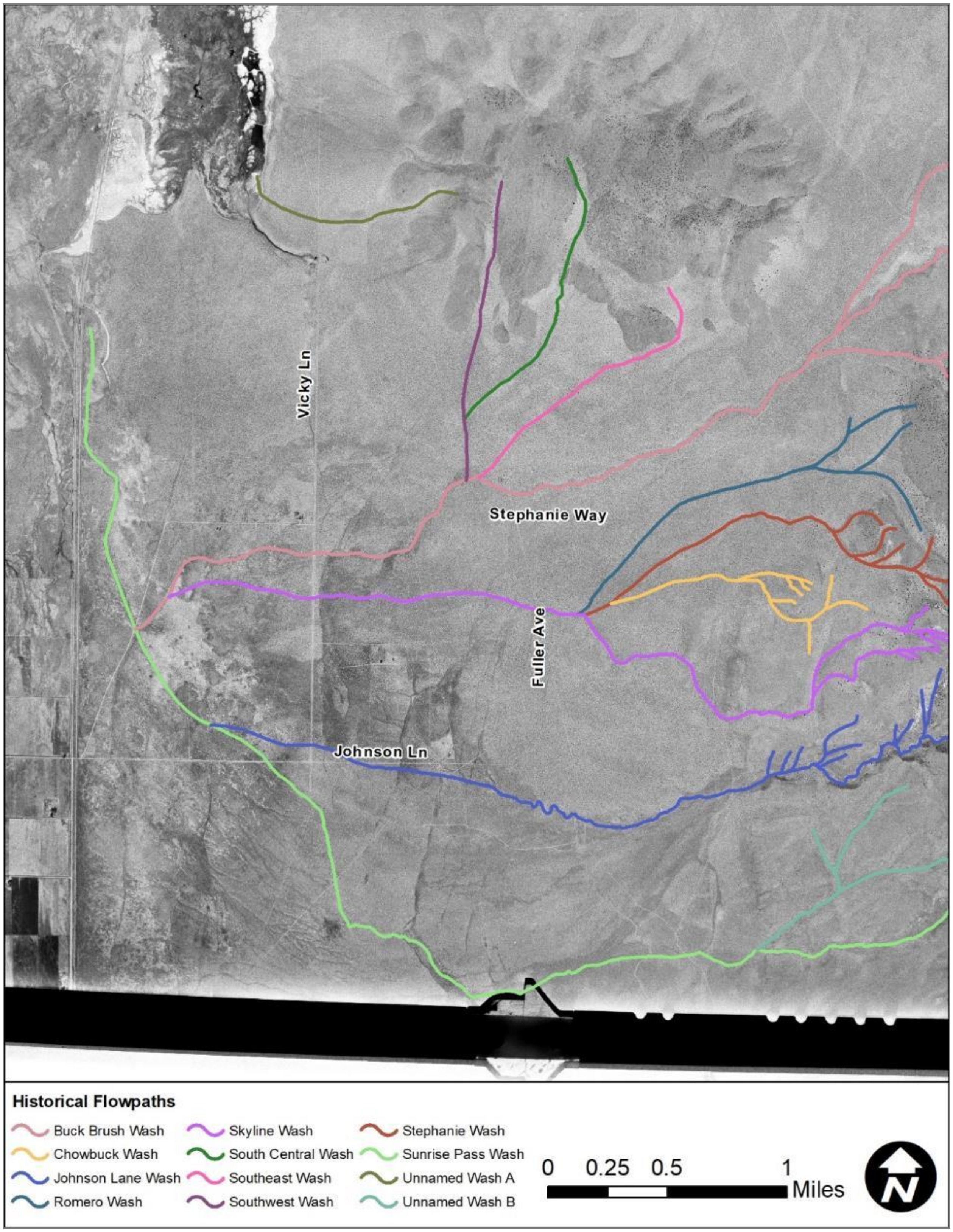

Figure 2-2. Historical flowpaths on 1954 photography

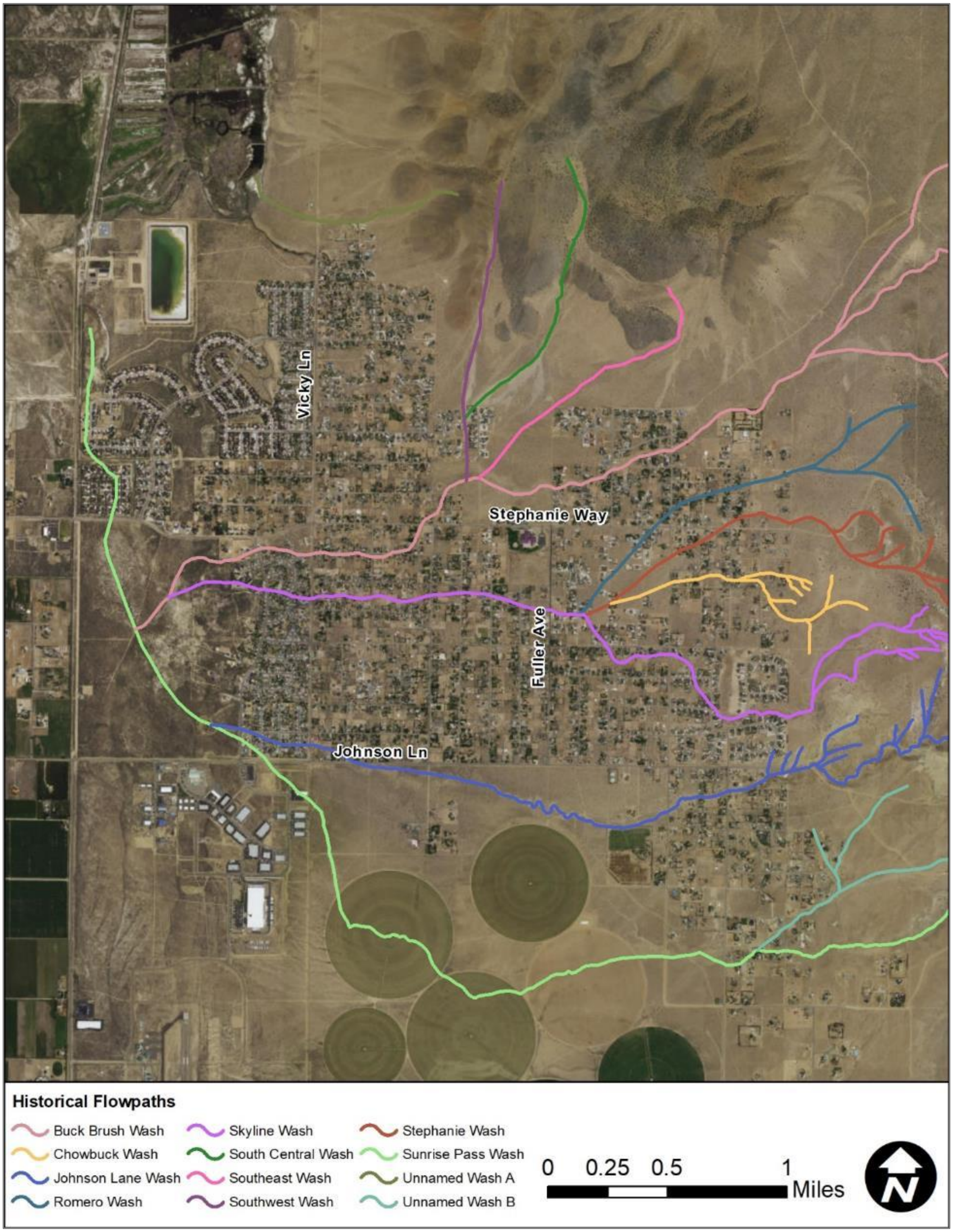

Figure 2-3. Historical flowpaths on 2015 photography

3 HYDROLOGIC MODELING

3.1 METHOD DESCRIPTION

All off-site hydrologic modeling was completed using the U.S. Army Corps of Engineers Hydrologic Modeling System (HEC-HMS) software package (version 4.2). The HEC-HMS modeling was used to generate inflow hydrographs for the detailed on-site FLO-2D two-dimensional hydraulic modeling (see Section 4). HEC-HMS was selected for use in the upper watershed areas that are generally characterized by tributary channel patterns and one-dimensional flow. One-dimensional rainfall-runoff models, like HEC-HMS, are highly efficient and well-established for computing hydrology in tributary flow areas.

The existing subbasin delineations from the recently revised FEMA Flood Insurance Study were reviewed and found to adequately define the drainage areas for JLADMP and were therefore not modified for this study. The FEMA study HEC-HMS model included subbasins throughout the entire Johnson Lane community (see Figure 3-1). For this study, only the subbasins upstream of the FLO-2D modeling area were used.

3.2 PRECIPITATION DEVELOPMENT

3.2.1 25-year and 100-year Storms

The Douglas County *Design Criteria and Improvements Standards* (2017) specify that storm drains and other drainage facilities be designed to convey the 25-year, 24-hour recurrence interval design storm. For compliance with these standards, the 25-year, 24-hour storm from the FEMA model was incorporated directly into the JLADMP HEC-HMS model. The Douglas County manual also specifies that the 100-year, 24-hour recurrence interval design storm be used under certain situations described in the manual, therefore, the 100-year, 24-hour storm was also integrated in the JLADMP HEC-HMS model. In addition, the 100-year, 6-hour storm was also added to the JLADMP HEC-HMS model.

3.2.2 Storm Events of July 8-9, 2015

During the summer of 2015, two large magnitude, short duration storm events occurred in the JLADMP study area on July 8th and 9th. The data from these storms were collected and investigated to determine their intensity and magnitude, and to provide guidance on how the watershed responds to shorter duration storm events. The outcome of this investigation was used to pick a shorter duration storm event to model in both HEC-HMS and FLO-2D.

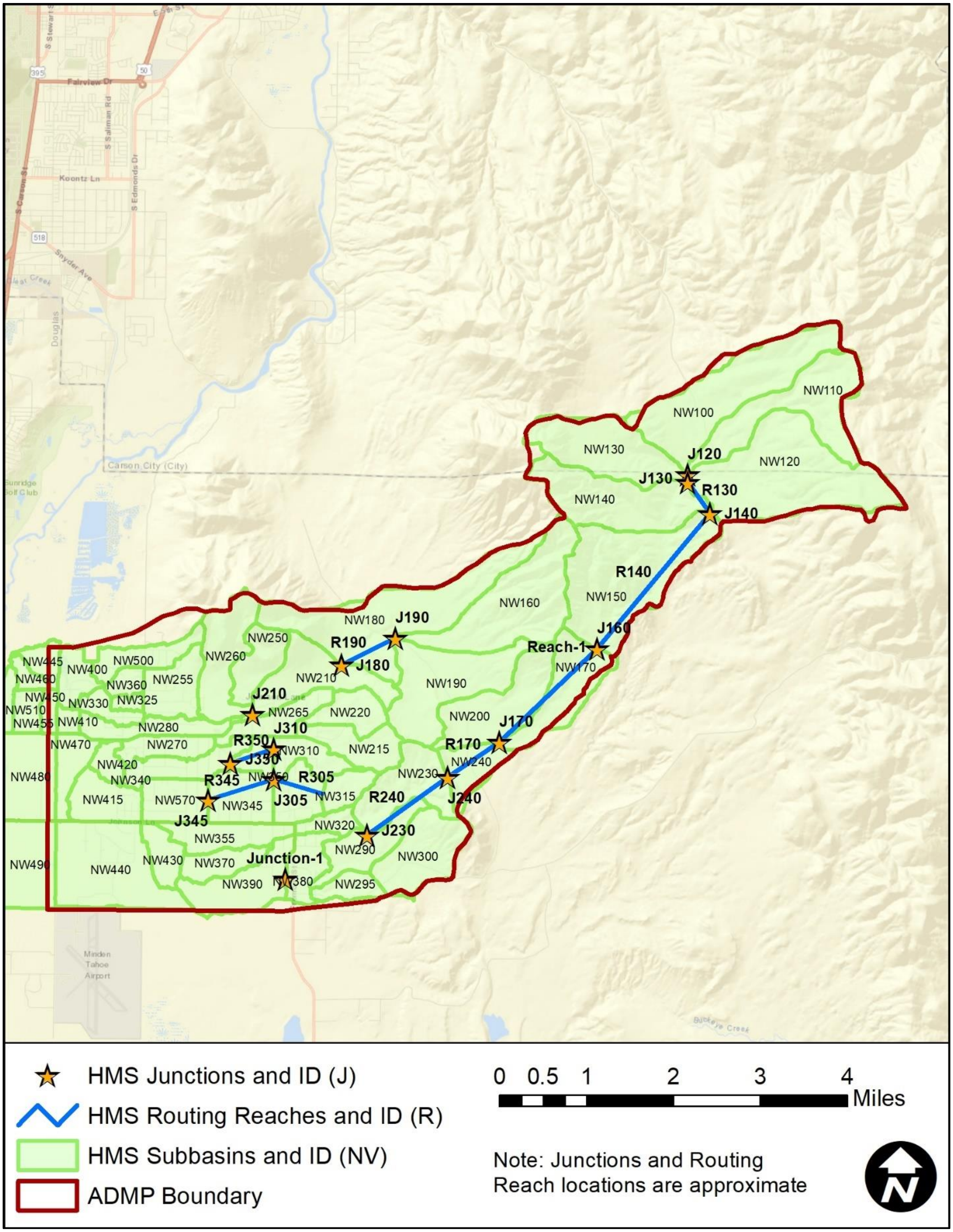

Figure 3-1. Subbasins from the FEMA study within the JLADMP study area

3.3 Infiltration Development

The Green and Ampt infiltration methodology was applied for this study and the following parameters were developed and incorporated into the HEC-HMS model

- Initial water content
- Saturated water content
- Wetting front suction in inches (PSIF)
- Saturated hydraulic conductivity in inches per hour (KSAT)
- Percent impervious

3.4 Results

The HEC-HMS results (both peak discharge and volume) are summarized in Table 3-1. The table indicates which upper watershed subbasin results were used in this study). A graphical comparison of the hydrographs at HMS ID J230 (the outflow for Johnson Lane Wash) is shown in Figure 3-2.

Table 3-1. HEC-HMS modeling results

HMS ID	Drainage Area	25-year 24-hour		100-year 24-hour		100-year 6-hour		Hypothetical July 2015 Storm	
		Peak Discharge	Volume	Peak Discharge	Volume	Peak Discharge	Volume	Peak Discharge	Volume
	(mi²)	(cfs)	(ac-ft)	(cfs)	(ac-ft)	(cfs)	(ac-ft)	(cfs)	(ac-ft)
NW120	1.777	152.9	38.4	308.1	77.7	381.6	95.7	232.9	54.4
NW100	1.379	76.3	22.0	180.1	52.2	221.3	63.8	142.1	36.7
NW110	1.024	104.6	39.0	199.6	83.5	218.0	63.4	134.8	34.9
J120	4.180	328.4	99.3	679.2	213.3	811.5	222.8	505.4	126.1
NW130	0.915	31.6	7.8	102.6	25.3	128.0	31.5	83.0	19.2
J130	5.095	359.5	107.1	780.1	238.7	936.7	254.4	586.4	145.2
R130	5.095	358.6	107.1	778.6	238.7	935.8	254.4	583.5	144.2
NW140	1.027	93.5	18.2	209.6	41.0	252.5	49.0	164.6	31.4
J140	6.121	432.2	125.3	946.5	279.7	1135.8	303.4	715.4	175.6
R140	6.121	432.2	125.3	944.5	279.8	1134.4	303.5	712.7	171.3
NW150	1.582	118.1	30.7	245.7	64.3	297.9	77.4	199.3	48.0
J150	7.704	534.8	156.1	1171.5	344.1	1410.0	380.9	900.0	219.3
Reach-1	7.704	534.6	156.1	1170.0	344.1	1408.6	380.9	895.4	214.1
NW170	0.668	26.7	6.1	80.8	18.5	98.3	22.4	74.2	16.4
J170	8.372	552.3	162.2	1229.5	362.6	1482.4	403.3	949.0	230.4
R170	8.372	551.5	162.2	1228.7	362.5	1481.1	403.2	948.7	227.7
NW200	0.802	0.0	0.0	33.4	6.2	59.9	11.1	21.9	4.0
NW240	0.352	0.0	0.0	9.9	1.2	22.8	2.8	1.6	0.2
J240	9.526	551.5	162.2	1247.9	369.9	1520.3	417.1	960.4	231.9
R240	9.526	550.5	162.2	1247.5	369.9	1519.2	417.0	957.9	227.5
NW230	0.652	38.0	7.7	102.8	21.1	116.7	23.7	106.0	21.2
J230	10.178	568.5	169.9	1302.2	391.0	1582.7	440.7	1012.5	248.7
NW160	1.289	60.9	10.4	194.8	33.2	220.5	37.6	154.6	26.7

HMS ID	Drainage Area	25-year 24-hour		100-year 24-hour		100-year 6-hour		Hypothetical July 2015 Storm	
		Peak Discharge	Volume	Peak Discharge	Volume	Peak Discharge	Volume	Peak Discharge	Volume
	(mi^2)	(cfs)	(ac-ft)	(cfs)	(ac-ft)	(cfs)	(ac-ft)	(cfs)	(ac-ft)
NW190	1.067	0.0	0.0	76.6	11.1	101.1	14.7	44.6	6.7
J190	2.356	60.9	10.4	266.3	44.2	317.8	52.3	199.2	33.5
R190	2.356	60.6	10.4	266.3	44.3	317.4	52.3	198.4	33.4
NW180	1.604	1.4	0.7	26.6	4.8	40.5	6.5	2.0	0.4
J180	3.960	61.9	11.1	291.0	49.1	357.0	58.8	200.3	33.7

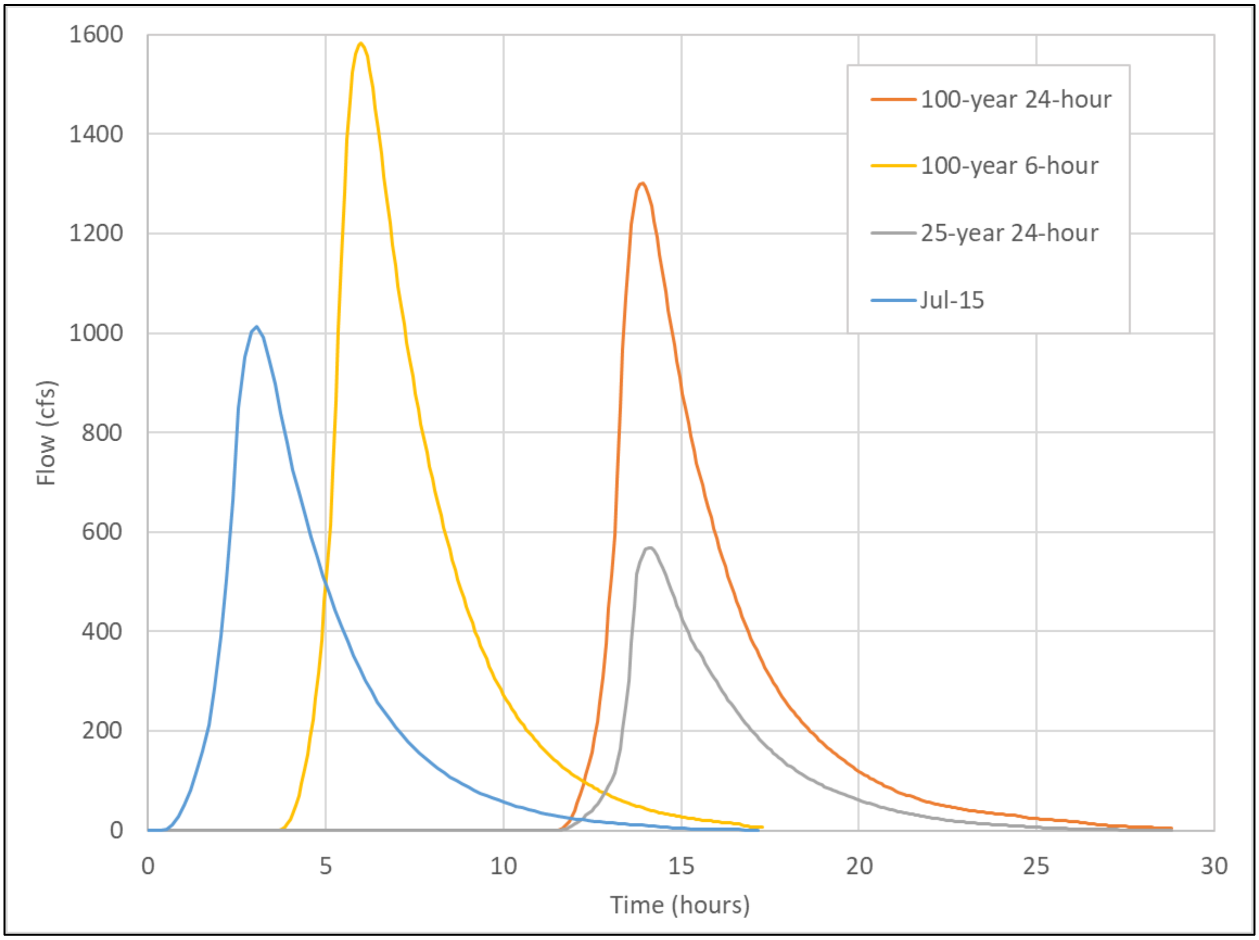

Figure 3-2. HEC-HMS hydrographs at HMS ID J230 (Johnson Lane Wash)

4 HYDRAULIC MODELING (BASE MODEL)

4.1 METHOD DESCRIPTION

Modeling for the on-site JLADMP study area was completed using the FLO-2D Pro software[1] package, Build No. 16.06.16 with an executable dated February 28, 2017. This version has been used for multiple area drainage master studies and has functioned adequately.

FLO-2D is a combined rainfall-runoff model (i.e., both hydrologic and hydraulic). Off-site modeling was completed using HEC-HMS, with inflow hydrographs from HEC-HMS being used at the upstream boundary of the FLO-2D model. On-site rainfall was applied to the FLO-2D model area.

4.2 MODEL PARAMETER DEVELOPMENT

4.2.1 Model Domain

The final domain comprised a modeled area of 14.3 square miles. The domain and inflow hydrograph locations are shown in Figure 4-1.

4.2.2 Grid Size

The JLADMP watersheds contain many small drainage features which were needed to be adequately captured in the model to provide the most accurate results. Some of these features include small 18-inch driveway culverts, roadside drainage ditches, and off-highway vehicle (OHV) roads in the upper watersheds. A high-resolution, 10-foot grid was selected to provide the necessary detail to model these features while maintaining reasonable model run times.

4.2.3 Grid Elevations

As a part of this project, LiDAR data was collected by aircraft at an average density of 4 points per square meter in June 2017. This detailed LiDAR data formed the basis on which the FLO-2D grid elevations were computed.

4.2.4 Grid Outflow

Outflow nodes were placed along the entire boundary of the model domain except near the location of the inflow hydrographs. This allowed water to flow off the domain at most locations except where the outflow nodes could erroneously affect the inflow hydrographs.

4.2.5 Grid Roughness

The FLO-2D model uses Manning's n value to estimate roughness on each grid. Each grid is assigned an average n value based on the underlying surface conditions. For this study, a detailed surface feature classification was developed by refining the Douglas County zoning dataset and adding more detail in areas where the zoning delineations were generalized.

[1] https://www.flo-2d.com/

4.2.6 Hydraulic Structures (Culverts and Storm Drains)

For this study, all hydraulic structures were simulated by developing rating tables for each structure. There is significant sediment transport in the study area, thus almost all culverts were simulated with a 50% blockage from sediment, including the box culvert at Johnson Lane and Vicki Lane.

4.2.7 Floodplain Cross-Sections

Floodplain cross-sections were developed and included in the FPXSEC.DAT file to query flow hydrographs, peak discharges, and flow volumes from the FLO-2D model at key locations, such as:

- Major flow concentration locations,
- Across roadside ditches and streets (used for driveway culvert assessment, see Section 7.2.4),
- Areas near potential mitigation sites, and
- Areas of interest to Douglas County

4.2.8 Hydraulic Modeling Results

An example of the flow depth and discharge results from the existing conditions FLO-2D modeling are shown on Figure 4-2 and Figure 4-3, respectively.

4.2.9 Summary

The existing conditions FLO-2D models were created using the best available information for land cover, land use, topography, and hydrology. Every effort was made to ensure the models represented existing conditions as of the date of the LiDAR survey. Photographs, videos, and anecdotal information collected from Douglas County and residents within the community were used to help calibrate and verify the modeling results. Like all models, the JLADMP FLO-2D models are a simulation of potential conditions that could occur during a range of storm events. The models cannot duplicate actual, observed storm events at all locations within the community due to the vast number of variables that change with each unique storm event.

The modeling results reflect the complex flooding and sedimentation hazards that exist with the Johnson Lane community. The results provide valuable, quantitative, detailed information from which future planning and development decisions can be based.

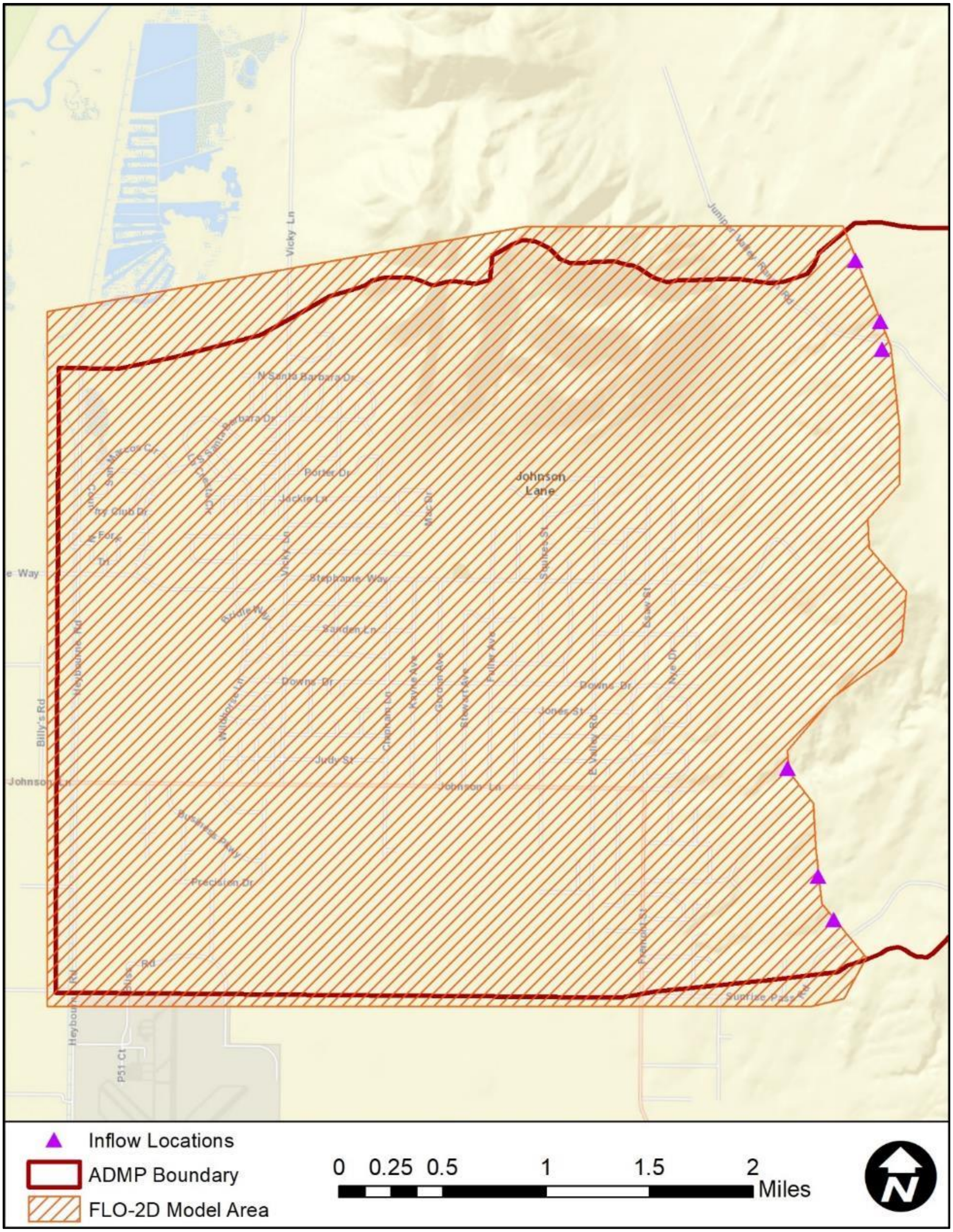

Figure 4-1. FLO-2D model domain and inflow locations

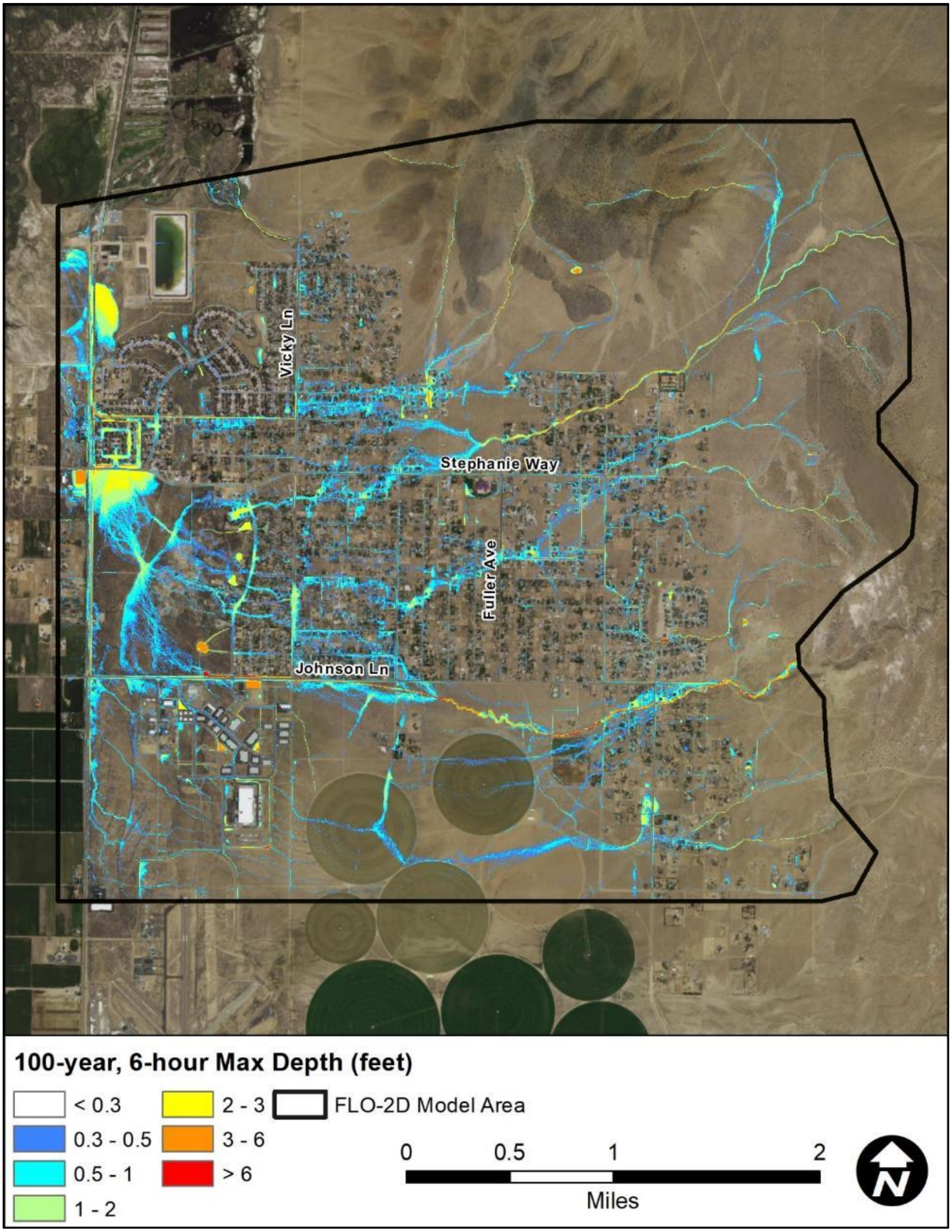

Figure 4-2. FLO-2D 100-year, 6-hour flow depth results

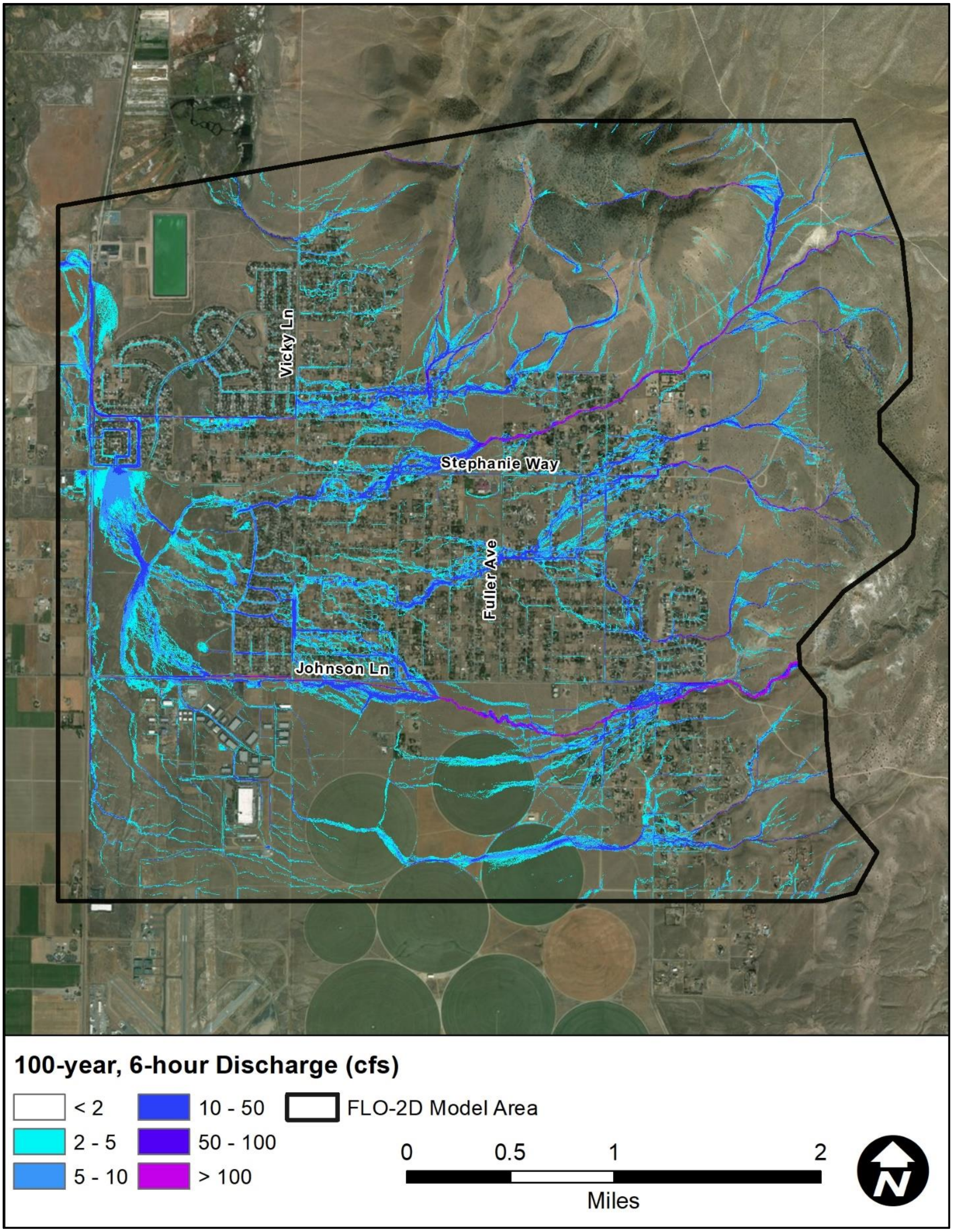

Figure 4-3. FLO-2D 100-year, 6-hour discharge results

5 SEDIMENT CONSIDERATIONS

5.1 SEDIMENT TRANSPORT ANALYSIS

Twenty sediment samples were collected in August 2017 to help classify the type of sediment being transported to and through the study area. Based on the results of the sampling analysis, the sediment in the watershed can overwhelmingly be classified as sand, with a large portion of that being fine sand. This means that the sediment in the area is highly transportable, and even small amounts of rainfall can lead to scour and deposition with large events showing extreme scour and deposition. The FLO-2D hydraulic modeling was used to ascertain the trends of both flooding and sedimentation throughout the study area. Hydraulic data from FLO-2D inherently includes both discharge and flow depth at each grid element. This hydraulic data was used to estimate sedimentation on a grid-by-grid scale.

5.1.1 Results

Using the 100-year, 6-hour storm as a representative example, the relative total accumulated sediment transport was computed. In general, the results show higher sediment transport rates in the channels, and that the mountains present a large sediment source. In fact, the Hot Springs Mountains appear to be the largest source of sediment. This is consistent with historical flooding and sedimentation accounts, and with field observations.

Finally, since these sediment results are based on hydraulic conditions, off-site inflows are considered because inflow hydrographs have been input at major watercourses, such as Buckbrush and Johnson Lane.

5.2 SEDIMENT YIELD

Sediment yield was computed for ten locations surrounding the study area. Modified Uniform Soil Loss Equation (MUSLE) was used alongside an approach developed for semi-arid rangeland in the southwestern United States.

5.2.1 Summary

The results from the sediment analyses were used in two important ways:

a) To quantitatively identify areas where sediment problems were most severe.
b) To estimate the additional sediment volume necessary for flood control basin design (project alternatives task described in Section 8).

For a), it was found that the watersheds draining Hot Springs Mountains produce the most sediment; and, therefore, sediment basins are recommended for any flood control capital project in these watersheds. For b), the total sediment volume for the proposed basins was calculated using three times the annual sediment volume plus the volume from one 100-year event. The annual sediment estimate was taken from the sediment yield analysis, while the 100-year sediment volume was evaluated based on the profile calculations for each watercourse. The design sediment volume of three times the annual sediment volume plus the 100-year event sediment volume was based on experience in other concept designs (JEF, 2006) and engineering judgment.

6 FLOOD HAZARD CLASSIFICATION

6.1 PURPOSE

During a severe storm event, flood waters flow throughout the Johnson Lane ADMP study watershed. However, not all flood hazards pose a risk to people or their properties. Flood risk depends on the presence of both a flood hazard and a person or their property. As an example, flow in a constructed flood control channel does not present a risk until someone enters the channel. Identifying areas where flood waters may cause risks that potentially harm people or their properties is an important objective of the Johnson Lane ADMP. Identification of potential flood risks in the study area helps the project team determine which flood problems should be addressed in the future.

6.1.1 Flooding Hazards

Flooding hazard assessments were conducted for pedestrians, passenger vehicles, and buildings. Pedestrian flood hazards were classified using the depth-velocity relationship outlined in the United States Bureau of Reclamation (USBR) Technical Memorandum 11 (TM 11). The depth-velocity relationships presented in TM 11 are a good basis for flood hazard classification since the criteria are widely accepted. TM 11 presents two possible classifications for pedestrians; flood danger levels for adults and for children. It was decided to use the flood danger classification for children throughout the entire watershed to simplify the methodology and to be conservative.

The following three flood hazard categories exist in TM 11 for pedestrian, passenger vehicles, and buildings:

- *Low*
- *Moderate*
- *High*

Finally, a *Very High* classification was added to the passenger vehicles analysis.

Potential hazards to passenger vehicles were classified using a combination of minimum depth criteria and depth-velocity relationship in TM 11 (Figure 6-1). Potential hazards to buildings were classified using the depth-velocity relationship from TM 11 (Figure 6-2), and hazards to structures were classified using depth (Figure 6-3). The tabulated building hazard results are shown in Table 6-1

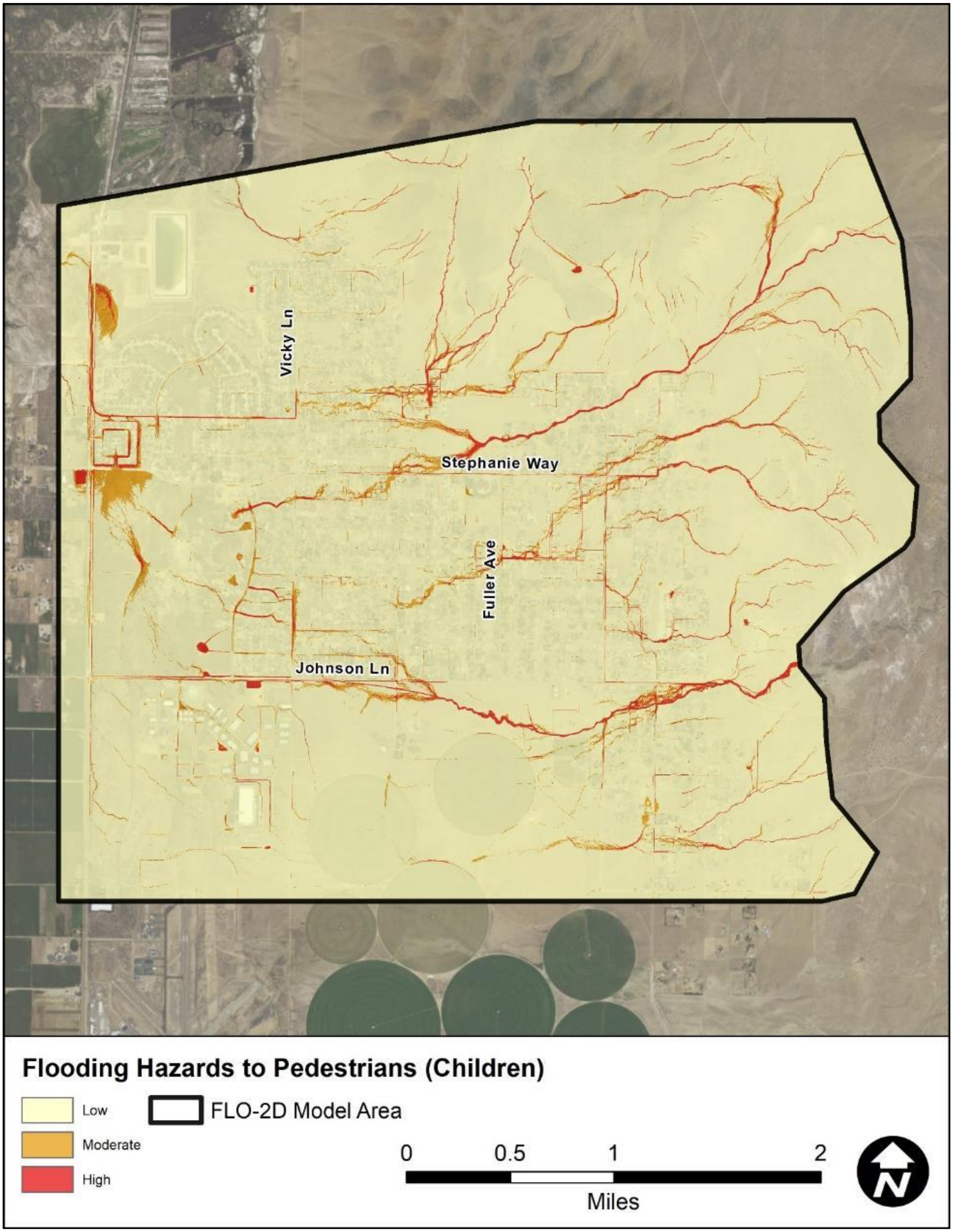

Figure 6-1. Flooding hazards to children based on the 100-year 6-hour FLO-2D results

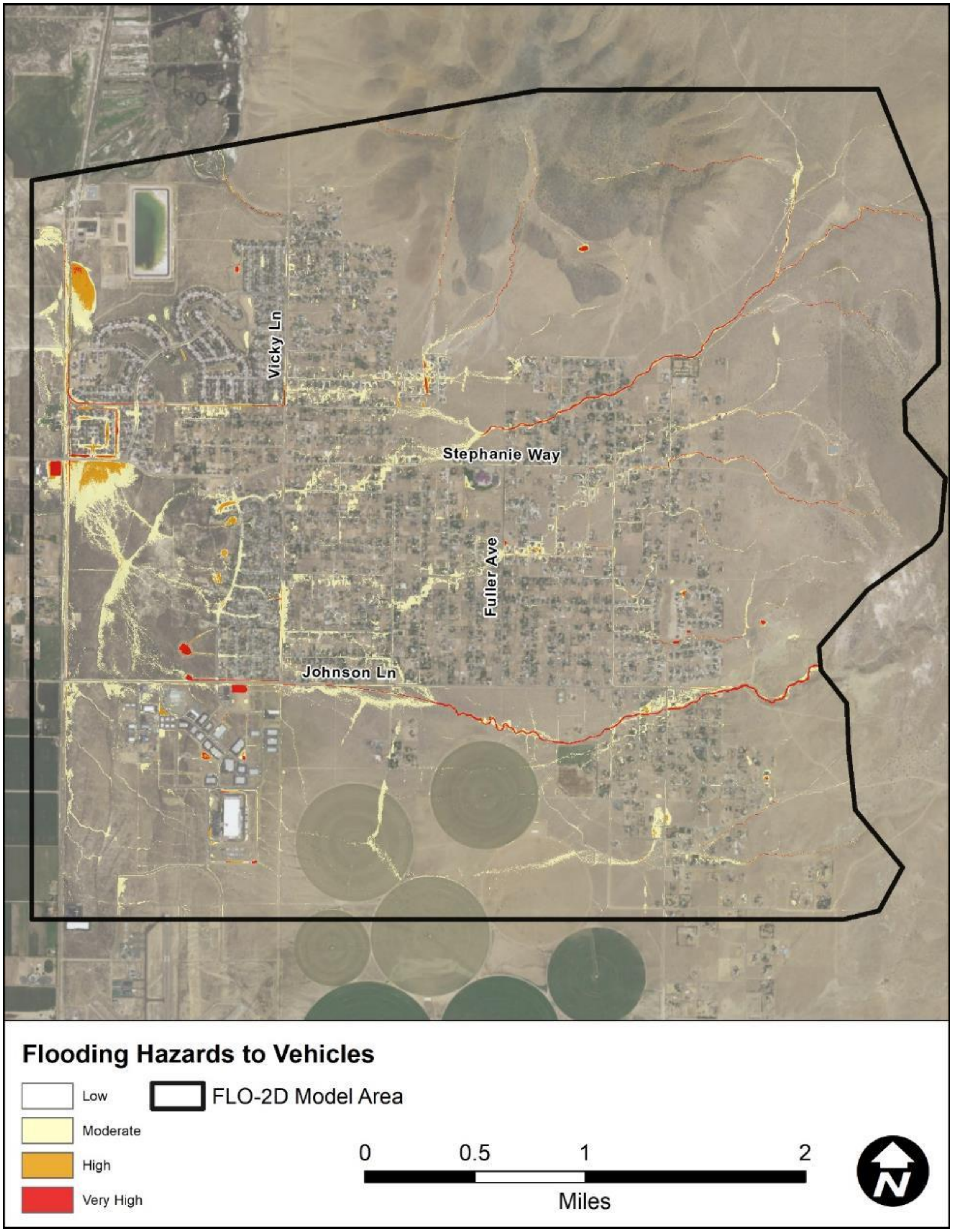

Figure 6-2. Flooding hazards to passenger vehicles during the 100-year 6-hour event

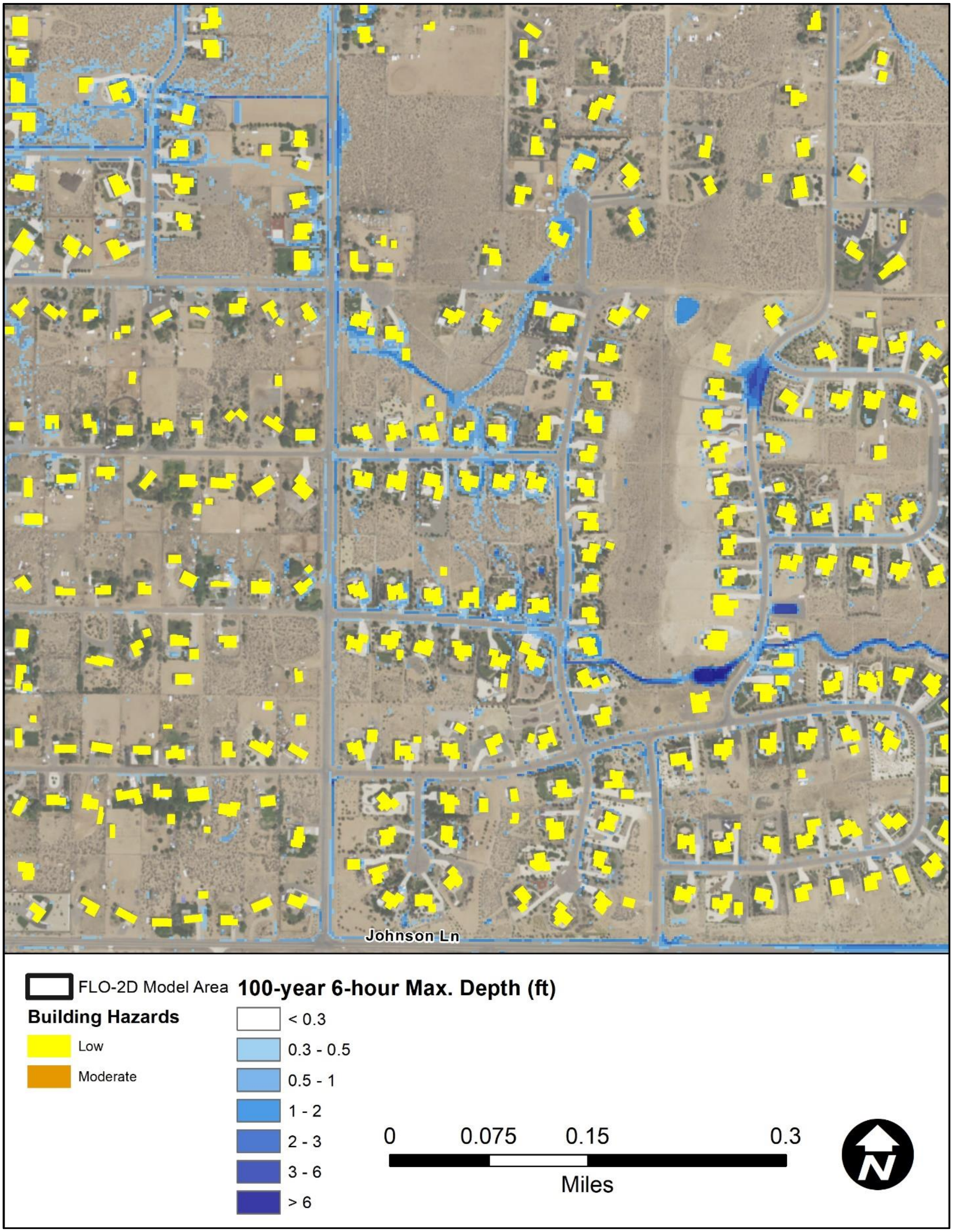

Figure 6-3. Building flooding hazard classification example for the 100-year 6-hour event.

Table 6-1. Buildings flooding hazard classification results (base conditions)

Base Conditions				
Recurrence Interval	Building Count Low	Building Count Moderate	Building Count High	**Total Building Count**
25-yr 24-hr	3531	1	0	**3532**
100-yr 24-hr	3528	4	0	**3532**
100-yr 6-hr	3529	3	0	**3532**
Hyp. July 2015	3529	3	0	**3532**

6.1.2 Building Inundation Assessment

Base Conditions

Each building in the study area was classified based on the maximum depth that fell within the building outline. The buildings were tabulated into four groups:

1) 0.25 ft < Depth (h) ≤ 0.5 ft – Low
2) 0.5 ft ≤ Depth (h) ≤ 1.0 ft – Moderate
3) 1.0 ft < Depth (h) – High
4) 0.25 ft < Depth (h) (inclusive of groups 1 through 3 above)

The results for existing conditions are tabulated in Table 6-2, while the results for the 100-year 6-hour storm are shown in Figure 6-4.

Table 6-2. Buildings that are impacted by various depths (base conditions)

Base Conditions				
Recurrence Interval	Building Count Flow Depth 0.25' < h ≤ 0.5'	Building Count Flow Depth 0.5'< h ≤ 1'	Building Count Flow Depth 1' < h	**Total Building Count** 0.25' < h
25-yr 24-hr	314	56	18	**388**
100-yr 24-hr	657	233	77	**967**
100-yr 6-hr	776	354	97	**1227**
Hyp. July 2015	765	247	61	**1073**

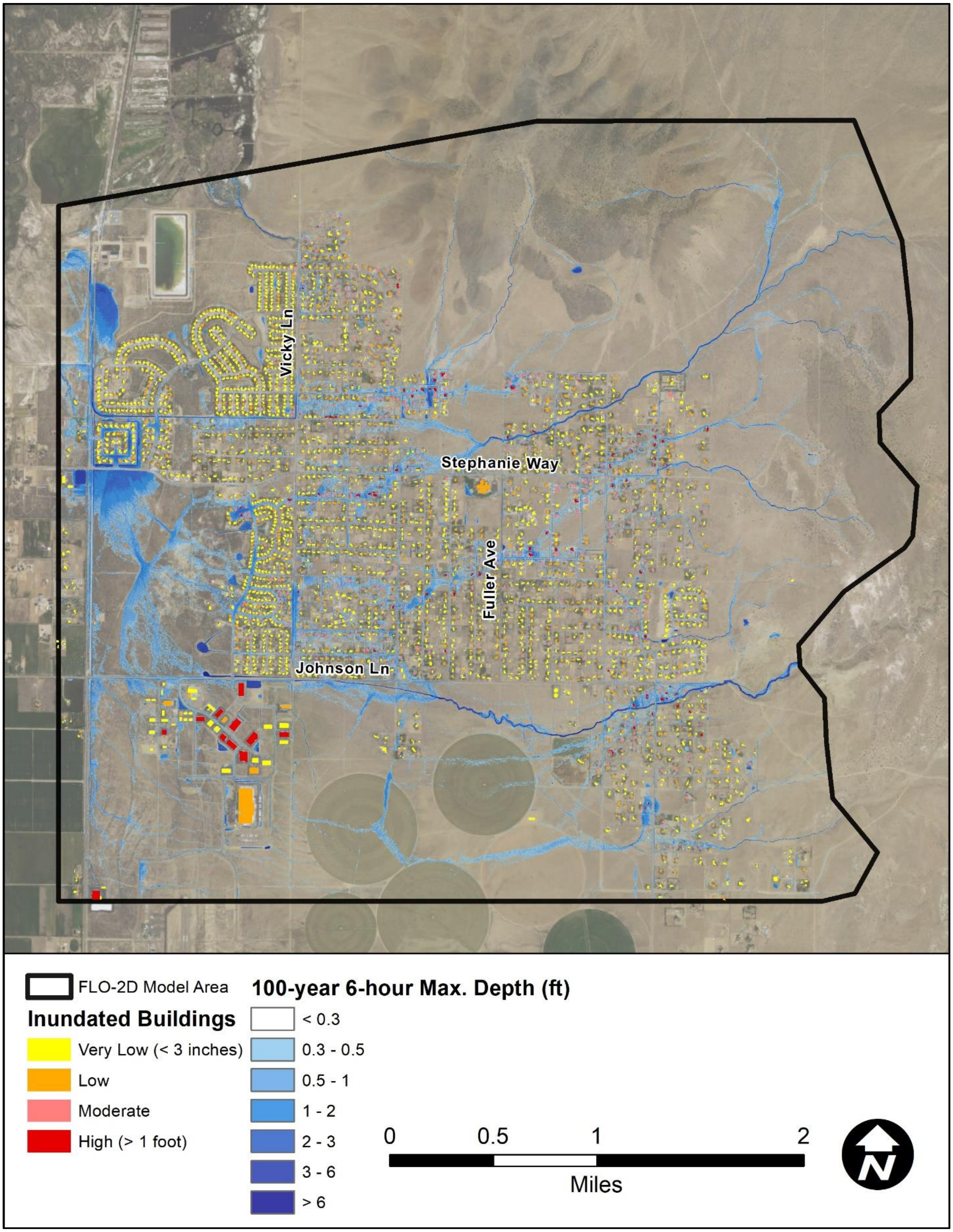

Figure 6-4. Buildings subject to potential inundation for the 100-year 6-hour event

6.1.3 HAZUS Event-Based Analysis

Methodology and Purpose

FEMA's HAZUS program[2] is a standardized computer software package that automates FEMA's methodology for estimating potential economic losses and human displacement due to natural disasters such as earthquakes, floods and hurricanes.

Base Conditions

A building-related economic loss HAZUS analysis was conducted and divided into two categories: direct building loss and business interruption losses. A results summary is presented as Table 6-3. From these results, the 100-year 6-hour storm event causes the most damage to the area, while the 100-year 24-hour storm is only slightly lower. This result is in line with the fact that shorter, more intense storms have the most impact in this watershed. Additionally, the hypothetical July 2015 event is estimated to cause $4.5 million in damages – a little over 80% of the estimate 100-year 6-hour damage.

Table 6-3. Summary of flood damage estimates (base conditions)

Base Conditions				
	Economic Loss			
Recurrence Interval	Residential $ millions	Total Property $ millions	Business Interruptions $ millions	Total Economic Loss $ millions
25-yr 24-hr	2.14	2.22	0.42	2.64
100-yr 24-hr	4.27	4.49	0.42	4.91
100-yr 6-hr	4.87	5.13	0.42	5.55
Hyp. July 2015	3.90	4.08	0.42	4.50

6.1.4 Summary

In this section, the methodologies and results from five separate hazards analyses were presented. These included:

- Flooding hazards to children
- Flooding hazards to vehicles
- Flood hazards to buildings
- Building inundation assessment
- HAZUS event-based analysis

These analyses help identify areas that have a higher risk of flooding and which property and infrastructure are most susceptible to damage. Having this information helps focus the mitigation alternative to areas where they are most needed. Additionally, the last two analyses (the building inundation assessment and the HAZUS analysis) help show if the proposed alternatives are reasonable and cost-effective. The HAZUS analysis is a FEMA approved methodology for computing potential economic losses and is a standard requirement for most grant applications.

[2] HAZUS-MH 4.0 (https://msc.fema.gov/portal/resources/hazus)

7 ALTERNATIVES FORMULATION

7.1 PURPOSE

An important element to any area drainage master plan is an assessment of potential mitigation alternatives. The previous sections of this report described the overall watershed setting, discussed the development of offsite and onsite hydrology, explained the development and results of two-dimensional hydraulic modeling, described the methodology and results of a sedimentation engineering analysis, and outlined flooding hazards for pedestrians, vehicles, and structures. In summary, all the analyses leading up to this section have identified the locations and magnitudes of flooding and sedimentation hazards for a range of frequency storms. Identifying the hazards is a critical first step. The second step is to evaluate potential alternatives that could mitigate the hazards.

7.2 ALTERNATIVES

Douglas County requested an evaluation of the viability of several specific alternative concepts that have been suggested by Community Members, Douglas County Commissioner Board Members, and Douglas County Engineering Staff. Each of the following specific alternatives were assessed as part of the JLADMP:

- **Potential Off-Road Vehicle Use Impacts** – Off-road vehicle use has resulted in the loss of natural vegetation and compaction of the soils within the public land areas. This alternative analysis evaluated whether the unpaved road network could result in adverse flooding and sedimentation conditions within the downstream community.
- **Individual Lot Management** – This concept explored whether flooding hazards within the community could be mitigated though implementation of an individual lot management plan rather than regional mitigation structures.
- **Individual Lot Retention** – This alternative analysis examined whether implementation of individual lot retention for storm runoff would be viable in mitigating the flooding hazards within the community.
- **Driveway Culvert Sizing** – This analysis was conducted to provide a community-wide template for recommended driveway culvert sizes.
- **Roadside Ditch Lining** – The roadside drainage conveyance ditches within the community are frequency burdened with sedimentation and require frequent maintenance by Douglas County via a mechanical scraper. This analysis explored which type of channel lining would be adequate to protect the bed and banks of the ditches from erosion while being compatible with the mechanical maintenance procedures.
- **All-Weather Access** – It is the desire of Douglas County to have all-weather, 100-year access for Johnson Lane, Stephanie Way, and East Valley Road. This alternatives analysis explored the viability of structural modification of only these roadways and right-of-way to permit all-weather access during 100-year frequency storm events.
- **Regional Structural Alternatives for 25-Year and 100-Year Storms (Section 8)** – This task evaluated a series of regional structures to mitigate both storm runoff and sediment for the 25-year and 100-year frequency storms. The structures evaluated included:

- **Contour Trenches** - This analysis explored the viability of using contour trenching in the upper watershed areas to reduce or eliminate the flooding and sedimentation hazards within the Johnson Lane community.
- **Detention Basins/Channels** – This analysis explored the potential reduction in flooding and sedimentation hazards through construction of a series of detention basins, interceptor channels, and conveyance channels.

Each of these alternative concepts are presented in detail in the proceeding sections. It is recommended that the decision to implement any one, or any combination of these alternatives be a collaborative effort between Douglas County and the residents of the Johnson Lane community.

7.2.1 Potential Off-Road Vehicle Use Impacts Results

The analysis results indicate unpaved roads directly result in both increase and decrease in discharge. An increase in discharge would be expected in areas where the unpaved road network could concentrate and divert runoff due to lower surface roughness, resulting in concentrations of flow in areas that would not see such concentrations absent the unpaved road network. In addition, the increase in runoff from soil compaction due to off-road vehicle use would also result in an increase in discharge. Areas of decrease in discharge would be expected where shallow, sheet flooding would be reduced by the runoff concentrating along the unpaved roads. The results between the 25-year and the 2015 storm are spatially similar, with the 2015 storm showing a higher magnitude of change.

Road closures and mitigation efforts would result in improved conditions. General recommendations for selecting OHV road candidates for closure are listed below:

- Roads with field evidence of flow interception or drainage integration
- Roads that intersect natural drainage corridors
- Roads that are within the floodplain of natural drainage corridors

7.2.2 Individual Lot Management Plan Results

One potential solution to drainage problems like those in Johnson Lane is to reduce flood risk by allowing residents to protect their properties on a parcel-by-parcel basis through an Individual Lot Management Plan (ILMP). An ILMP can be an effective tool in flood hazard mitigation if the entire impacted community is in compliance with the plan. Random parcel mitigation activities can result in adverse impacts to downstream neighbors by diverting, concentrating, and discharging flows to locations that previously did not experience a flooding problem. Developing a set of mitigation measure templates can assist residents with protecting their property while being compliant with the ILMP. Example categories might include:

1. Engineered berms
2. Engineered swales and channels
3. Engineered driveway crossings

The result of this analysis suggests that the adverse impacts of random berm construction can be significant, and berm construction should not be initiated without a full impact analysis.

7.2.3 Individual Lot Detention Results

Individual lot detention can be accomplished by a variety of Low Impact Development (LID) methods. The most common is a detention basin which is an excavated area installed on, or adjacent to, areas of stormwater accumulation whose purpose is to reduce flow accumulation and flooding downstream. A few key assumptions were made for this analysis:

1. Every residential and commercial parcel owner within the analysis area would be required to participate in the lot detention plan.
2. The detention plan would apply to all parcels outside of the master planned community areas. It is assumed that the master planned communities have accounted for the excess volume from impervious areas through storm drain networks and neighborhood detention basins.

The analysis results suggest that the discharge reduction for the 25-year, 25-hour storm is minimal. The largest reduction in discharge is from the Stephanie Wash/Chowbuck Wash/Skyline Wash systems. These washes have a significantly smaller drainage area than Buckbrush Wash or Johnson Lane Wash, thus the offsite flow accumulation is lower. An individual lot detention policy for these drainage systems would be more effective than the other systems in the study area at reducing (but not eliminating) the flooding hazards. Both the 25-year and 100-year results suggest that offsite flooding from the surrounding watershed areas and not local runoff are the overall primary source of flooding within the Johnson Lane community.

7.2.4 Driveway Culvert Sizing Assessment Results

The main drainage infrastructure throughout the study area is small roadside ditches. Access to many of the residences is via a driveway that crosses a roadside ditch. The driveways typically have small culverts that are designed to allow passage of runoff from small storm events. Douglas County drainage standards (2017) require that driveway culverts are sized for the 25-year 24-hour event, but residents have historically been allowed to place the minimum required 15-inch culvert without runoff calculations to justify an undersized culvert.

Based on the results of this analysis, the following minimum recommendations are made:

- Use an 18-inch circular corrugated metal pipe (CMP) for flows less than 6 cfs.
- Use a 24-inch circular CMP for flows greater than 6 cfs but less than 16 cfs.
- Use a 30-inch circular CMP for flows greater than 16 cfs.

7.2.5 Roadside Ditch Lining Alternatives Results

Most of the streets within the study area were originally built with shallow unlined drainage ditches. Bed and bank scour of the drainage ditches is an adverse issue that consistently faces Douglas County. Throughout most of the study area, the drainage ditch bed and banks are comprised of native sediment derived from the upper watersheds. An analysis was conducted to determine which roadside ditches within the community are the most susceptible to scour and erosion. This was accomplished by isolating flow velocities that occur within the ditches and determining which areas are subject to erosive velocities. The analysis results identified locations where a roadside ditch lining is recommended to prevent future erosion. Check dams were also investigated as mitigation for scour, however are not recommended as erosion mitigation. Table 7-1 lists each of the lining alternatives and which would be compatible with the County's maintenance procedures for the ditches.

Table 7-1. Ditch lining alternatives

Lining Alternative	Compatible with Scraper?	JLADMP Recommended	Notes
Rock Rip-Rap	No	No	Rock lining of the channels by residents has been historically problematic for the mechanical scraper.
Synthetic Liners	No	No	Easy to install, but would not be viable long-term. Mechanical scraper would break-down the material over time.
SmartDitch Liners	No	No	Easy to install, but would not be viable long-term. Mechanical scraper would break-down the material over time.
Concrete Cloth	Yes	Yes	Benefits over shotcrete and soil cement are: fast installation time (20,000 sf/day), conforms to ditch geometry, small crew can install, no special equipment needed.
Shotcrete (or sprayed concrete)	Yes	Yes, with proper application	Shotcrete is a concrete or mortar mix sprayed onto a pre-formed surface at high pressure. It requires a steel fiber or mesh form over the structure. It is not typically used for small ditches. Durability is very dependent on proper construction/application techniques. Depending on the installation technique, shotcrete is typically not aesthetically pleasing.
Soil Cement	Yes	No, due to size	A mixture of natural soil and cement. Can be more cost effective than concrete if adequate soils are readily available. Generally needs 55% of the soil material to be finer than 4.8 mm, 35% to be finer than 0.074 mm, and no material greater than 51 mm. The abundance of fine sand in the JLADMP study area may be suitable for soil cement applications. However, due to the size of the construction lifts, may not be suitable for use in narrow drainage ditches.
Unreinforced Concrete	Yes	Yes	Second highest cost option, but highly durable over time. The material most compatible with the mechanical scraper. Hydraulically efficient to effectively transport water and sediment. Estimated life of this lining is 15+ years (USDA-NRCS, 1997)
Reinforced Concrete	Yes	Yes	Highest cost option, but highly durable over time. The material most compatible with the mechanical scraper. Hydraulically efficient to effectively transport water and sediment. Estimated life of this lining is 20+ years (USDA-NRCS, 1997)

7.2.6 All-Weather Access Results

The 2016 Douglas County Transportation Plan proposes Johnson Lane, Stephanie Way, and East Valley Road as designated collector roadways. The proposed collector roadways were investigated for the ADMP to determine how to ensure these roads have all weather access in storm events up to the 100-year. The analyses indicate that despite substantial infrastructure improvements for all-weather access (culverts, diversion dikes), the community would experience an increase in flooding depths at various locations, which is an unacceptable outcome. The study concluded that raising the roads and adding culverts to allow for all-weather access may not be the most cost-effective mitigation solution. The results suggest that perhaps more regional solutions, such as channeling the washes to contain flow and providing more efficient pass-through structures or constructing detention/sediment basins upstream of the developed areas may be more cost effective in achieving all-weather access for Stephanie Way, Johnson Lane, and East Valley Road. Therefore, based on the results of this analysis, it is recommended to pursue all weather access improvements with the implementation of off-site regional structural flood mitigation alternatives

8 REGIONAL FLOOD MITIGATION ALTERNATIVES

The Johnson Lane community experiences frequent adverse flooding and sedimentation impacts. The primary challenge in addressing the impacts is the overall lack of consistent stormwater drainage infrastructure within the community. The pre-development setting of the Hot Springs Mountains and the Pine Nut Mountains were a series of natural drainage corridors that extended from the upper watersheds, across the piedmont surface, to the Carson River floodplain which functioned to transport stormwater runoff and sediment. As the Johnson Lane community was established, the natural corridors were not preserved. Consequently, stormwater runoff and sediment have been forced to find alternate paths to the river floodplain. Those paths include small roadside drainage ditches, streets, residential yards, and homes. The general lack of vacant land and available right-of-way eliminates the potential to re-establish a corridor connection from the upper watersheds to the river floodplain. A wide-range of local, onsite flood and sediment mitigation alternatives were investigated for this study and are described in detail in Section 7. The hydrologic and hydraulic modeling efforts of this study indicate that most of the adverse flooding and sedimentation issues within the community are the result of offsite stormwater flows and not local onsite drainage. The analyses generally concluded that onsite mitigation alternatives can be beneficial in reducing flooding hazards, but that their impact is localized. All of these factors (lack of drainage corridors, lack of major drainage infrastructure, and minimal impact from onsite mitigation alternatives) suggest that the most viable alternative to mitigating the flooding and sedimentation risks is offsite, regional structures.

A series of regional solutions were investigated to assess their effectiveness in minimizing the impacts of flooding for both the 25-year and 100-year storms. The regional solutions are segregated into the following two categories:

- Contour Trench Analysis (Section 8.1)
- Detention Basin/Channel Analysis (Section 8.2)

The development of the regional alternatives comprised the following elements:

1) Flood hazard identification
2) Alternative formulation/evaluation
3) Development of conceptual 15% design plans and cost estimates (Detention Basin/Channel analysis only)

8.1 CONTOUR TRENCHING CONCEPT

Douglas County tasked the project team to investigate the viability of using contour trenching in the upper watershed areas to reduce or eliminate the flooding and sedimentation hazards within the Johnson Lane community. The basic concept is to capture storm runoff and sediment where it falls and allow for enhanced infiltration and percolation into the soil, thus eliminating flow accumulation downstream. The treatments are constructed by cutting a series of zero-grade trenches of the designed capacity and spacing into the hillslope that follow the natural contour, with small check dams or baffles constructed across the trenches to segment them.

8.1.1 Contour Trenching as a Long-Term Mitigation Solution

The literature on contour trenching is generally consistent in the conclusion of its effectiveness in reducing downstream flooding and sedimentation, especially in watershed rehabilitation scenarios. In evaluating the potential viability of contour trenches for the JLADMP, the following should be considered:

- Impacts on Watershed Viewscape Character
- Environmental Impact
- Maintenance

A pilot area within a portion of the Pine Nut Mountains was selected to conduct a rainfall-runoff simulation on the potential impacts of contour trenching. Two storms were assessed: 100-year, 6-hour, and the hypothetical July 2015. The flow depth reduction estimated with the FLO-2D modeling results for the contour trenching simulation is shown in Table 8-1 and Table 8-2.

Table 8-1. 100-year, 6-hour storm peak flow and volume results from each FLO-2D floodplain cross-section

Wash Name	Floodplain Cross-Section ID	Existing Conditions		With Contour Trenches		Percent Reduction in Peak Discharge
		Flow Peak (cfs)	Volume (ac-ft)	Flow Peak (cfs)	Volume (ac-ft)	
Stephanie	10	128	3.7	99	2.6	23
Romero	11	439	11.8	159	6.4	64
Skyline	12	281	8.0	108	4.0	62
Chowbuck	21	51	1.5	51	1.5	0

Table 8-2. Hypothetical July 2015 storm peak flow and volume results from each FLO-2D floodplain cross-section

Wash Name	Floodplain Cross-Section ID	Existing Conditions		With Contour Trenches		Percent Reduction in Peak Discharge
		Flow Peak (cfs)	Volume (ac-ft)	Flow Peak (cfs)	Volume (ac-ft)	
Stephanie	10	101	2.9	96	2.1	5
Romero	11	409	9.0	119	3.6	71
Skyline	12	200	5.5	68	2.2	66
Chowbuck	21	48	1.3	48	1.2	0

8.1.2 Contour Trench Cost Estimates

A cost estimate analysis was completed for the contour trenching treatment described previously. Table 8-3 lists the cost estimate for contour trenches (construction and operation/maintenance) assuming the linear feet of trench used in the FLO-2D analysis. Note: the operation and maintenance cost estimates are based on the following assumptions:

- At least two inspections annually (one annual inspection and one post-flood inspection).
- At least 5% of the total linear feet of trenches would need maintenance repair annually. Potential damage to the trenches could occur from natural storm events or from public access such as damage from off-highway vehicles.
- All costs shown in Table 8-3 are applicable for the FLO-2D pilot area. Contour trench treatment costs for a larger or smaller watershed area would need to be recomputed.

Table 8-3. Contour trench construction cost estimates

Estimated Construction Costs					
Item No.	**Description**	**Unit**	**Quantity**	**Unit Price**	**Cost**
1	Trench Excavation	Cubic Yards	102,393	$5	$512,000
2	Native Vegetation Finish	Acres	18	$5,000	$90,000
				Subtotal Construction:	**$602,000**
		Construction contingency		30%	$180,600
				Total Construction:	**$782,600**

Estimated Operation and Maintenance Costs					
Item No.	**Description**	**Unit**	**Quantity**	**Unit Price**	**Cost**
1	Inspection (2-Man Crew)	Hours	32	$175/hour	$5,600
2	Maintenance/Repair	Cubic Yards	5,120	$5	$25,600
				Total Annual Costs:	**$31,200**

8.1.3 Conclusions and Recommendations

The results of the pilot area contour trenching analysis suggest that contour trenching can provide a reduction of flooding hazards for selected watershed within the Johnson Lane Community. The cost analysis results suggest a contour trench treatment for Romero, Stephanie, and Skyline Washes could potentially be lower than a detention basin alternative, however the overall flood hazard reduction benefit is lower (see Table 9-2, Pine Nut North for comparison).

Based on the research conducted on contour trenching for this study, it is not recommended as a preferred regional solution to mitigating the flooding and sedimentation hazards in the Johnson Lane community at this time. This recommendation does not limit Douglas County from pursuing contour trenching as a flood mitigation solution in the future. If the Douglas County Federal Land Bill[3] were to become effective in transferring public land to Douglas County, a contour trenching treatment alternative may be more viable.

8.2 Detention Basin/Channel Concept Design Characteristics

A total of 11 regional basins with a series of collector and conveyance channels were selected for this study (Figure 8-1). Although each individual basin functions to reduce the flooding and sediment hazards downstream, they are designed to work together as a system. To quantify their impact, the basins were grouped into four “systems” listed in Table 8-4 and illustrated in Figure 8-2.

[3] https://www.douglascountynv.gov/894/Conservation-Bill

Table 8-4. Detention/Sediment basin system nomenclature

System Name	Included Basins
Unnamed A	Unnamed Wash A Basin
Hot Springs-Buckbrush	Southcentral Wash Sediment Basin Southeast Wash Sediment Basin Buckbrush Wash Sediment Basin (and alternate location) Johnson Lane Park Detention Basin
Pine Nut North	Romero Wash Detention Basin Stephanie Wash Detention Basin Chowbuck Wash Detention Basin Skyline Wash Detention Basin
Pine Nut South	Unnamed Wash B Detention Basin Sunrise Pass Wash Detention Basin

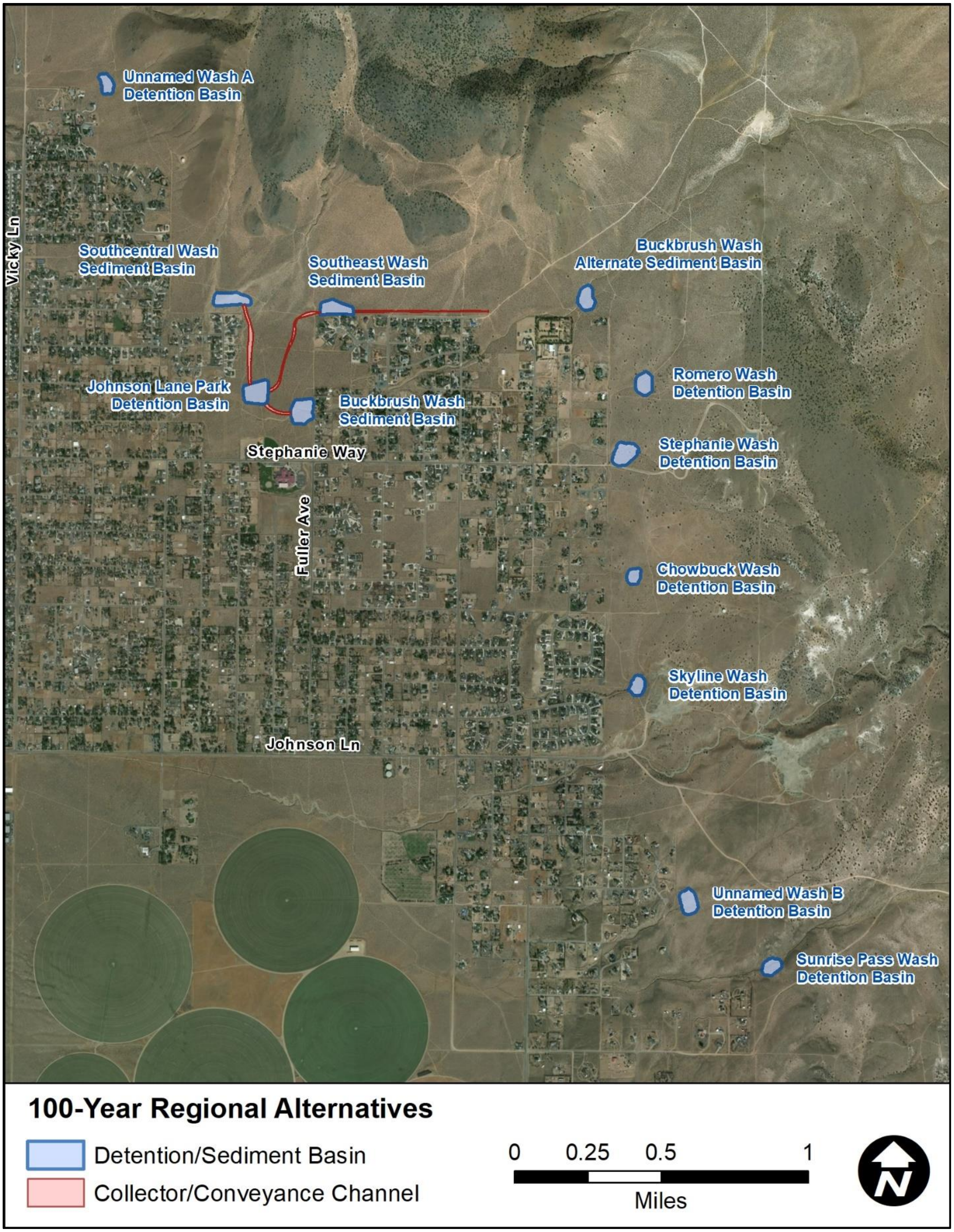

Figure 8-1. 100-year regional basins and channels

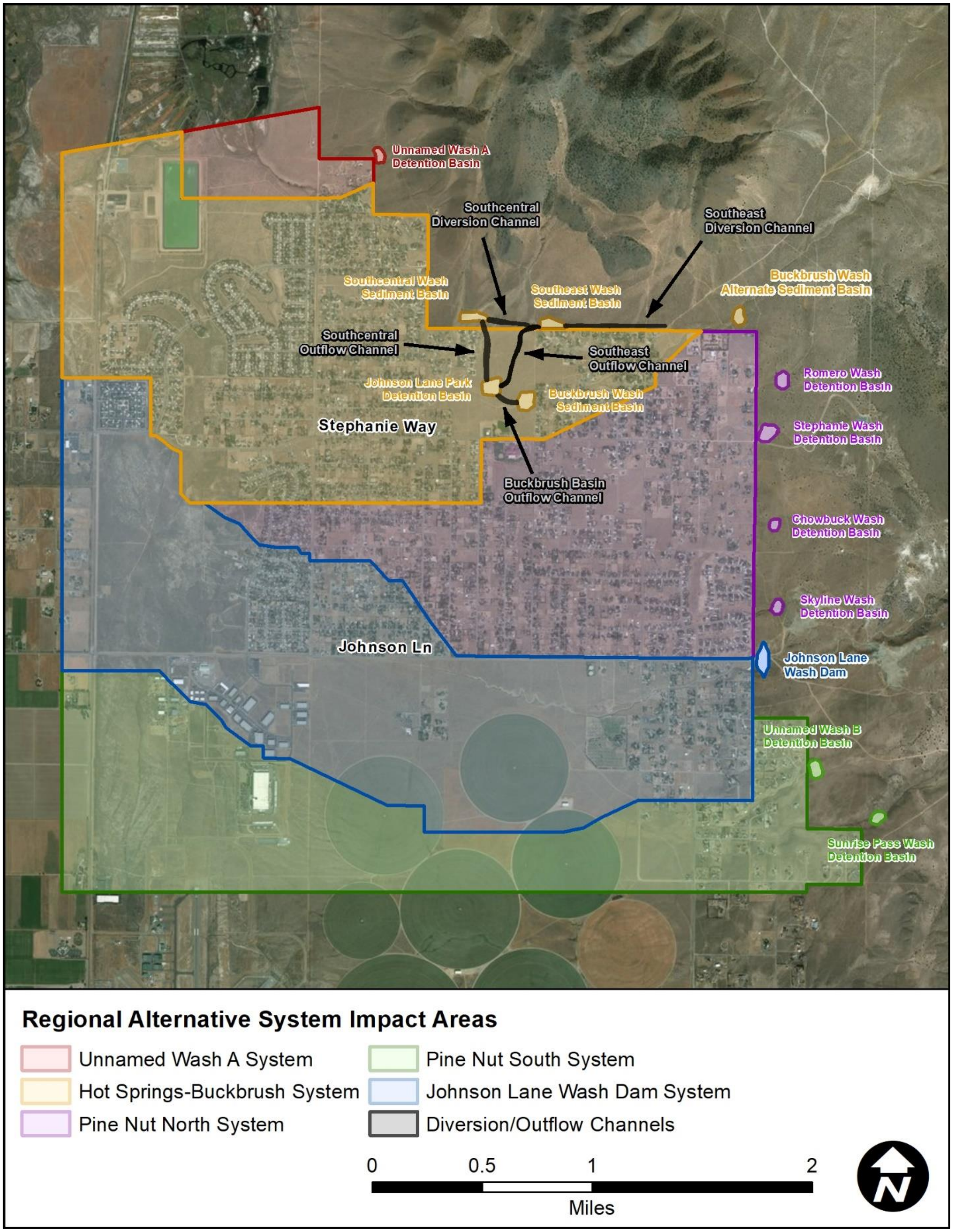

Figure 8-2. Alternative system impact areas

8.2.1 Basin System Flood Mitigation Conceptual 15% Design Plans

Conceptual 15% design plans for the 25-year and 100-year systems were developed. An example design plan for the 100-year Southeast Wash Sediment Basin is shown below in Figure 8-3.

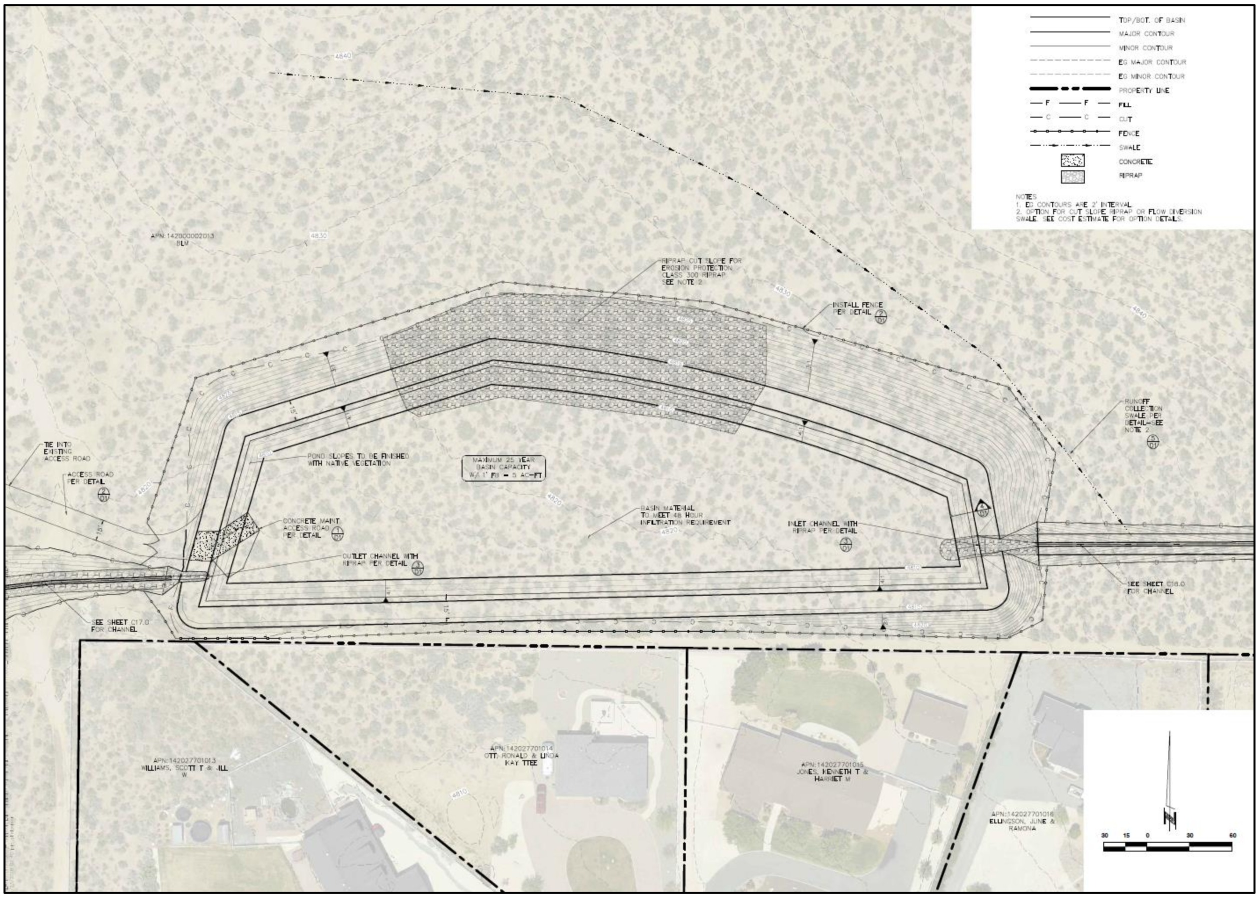

Figure 8-3. 100-year Southeast Wash Sediment Basin conceptual design plan

8.3 JOHNSON LANE WASH DAM ALTERNATIVE

Detention basin alternatives for Johnson Lane Wash were investigated both on BLM land and within undeveloped property downstream of East Valley Road. An upstream basin on BLM is not feasible because the Johnson Lane Wash floodplain is inset within a narrow geologic corridor with significant slope. A basin with sufficient storage capacity to mitigate the 100-year storm could not be sited within this corridor without raising the downstream basin embankment effectively creating a dam. A basin downstream of East Valley Road was also investigated, however it was also determined to be impracticable because 1) the immense basin size required to mitigate flooding downstream, and 2) it would not mitigate flooding hazards to the properties between East Valley Road and the MacKay Way alignment.

A brainstorming meeting with the project team and Douglas County resulted in the conclusion that a dam structure was the most feasible option for Johnson Lane Wash. For the current conceptual design, the basic design assumptions from the Smelter Creek Regional Flood Control Project Feasibility Engineering Study were used as a starting point since this project is also a dam in a similar watershed in Douglas County.

The location of the dam for this conceptual analysis is approximately 250 feet upstream of the MacKay Street alignment (Figure 8-4).

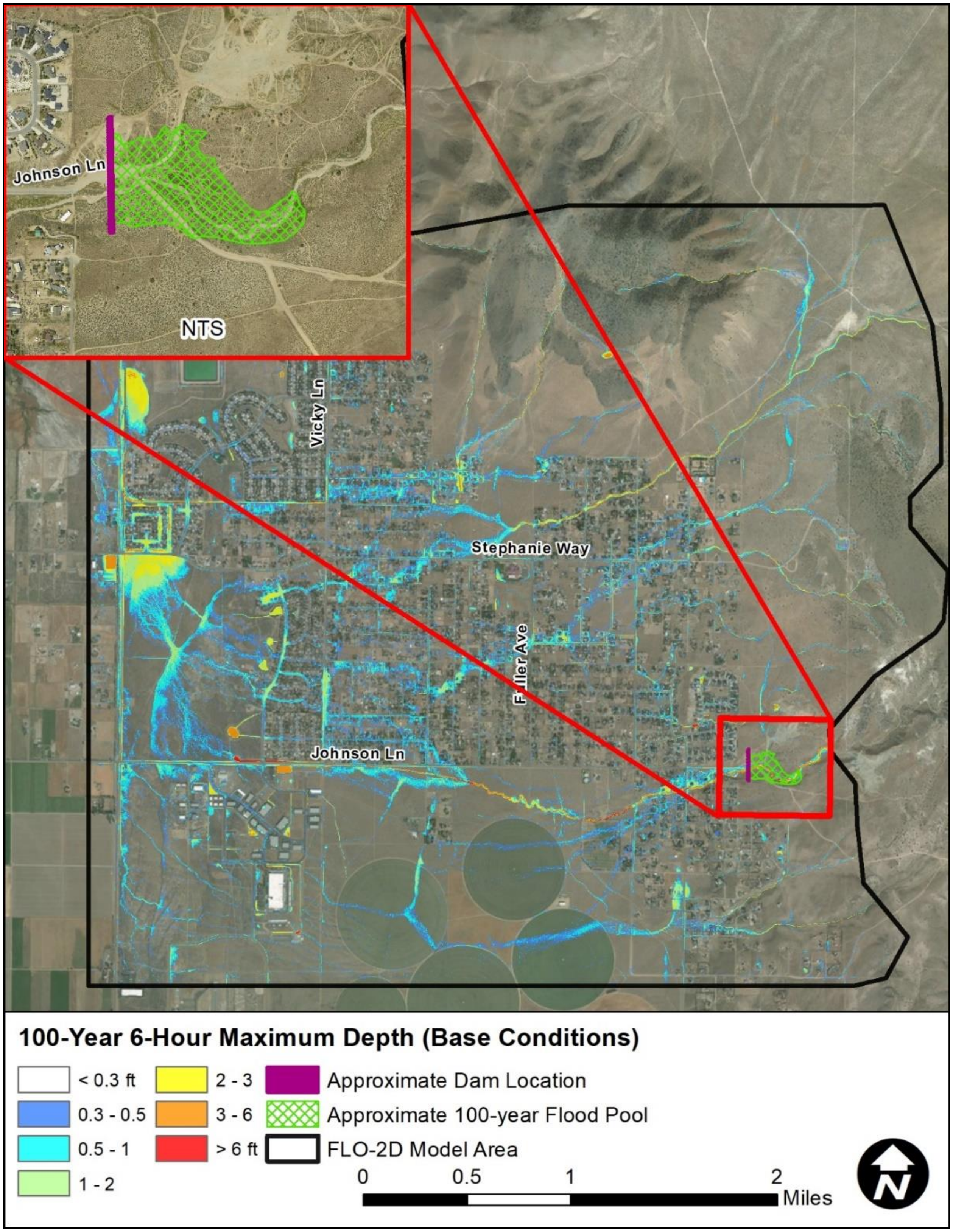

Figure 8-4. Approximate dam location

8.4 BENEFITS SUMMARY

The depth and HAZUS analyses that were performed for existing conditions were repeated for the proposed conditions. The analyses were run using three scenarios for each of the four storm events for a total of 12 proposed conditions models. The scenarios were:

1) All 25-year Regional Basins in place (no dam)
2) All 100-year Regional Bains in place (no dam)
3) The Johnson Lane Wash Dam in place (no regional basins)
4) All 25-year Regional Basin and Johnson Lane Wash Dam in place
5) All 100-year Regional Basins and Johnson Lane Wash Dam in place

The proposed conditions depth analyses are summarized in Table 8-5. In this table, the last column shows the estimated number of buildings removed from potential inundation by depths greater than 0.25 feet (3 inches).

The proposed conditions HAZUS analyses are summarized in Table 8-6. The last column in the table shows the estimated benefit (e.g., reduction in economic losses by flooding) for each storm event when compared to existing base conditions (shown in Table 6-3) for that same storm event. The results from these two analyses were used to identify the most effective systems and to recommend an initial phasing plan (Section 9).

A separate analysis was performed to evaluate the potential option of a property buy-out in lieu of constructing a dam for Johnson Lane Wash. The results are summarized in Table 8-7 and suggest that a property buy-out is likely less cost effective than constructing a dam for flood mitigation.

Table 8-5. Summary of depth analyses for the three proposed conditions scenarios

Recurrence Interval	Proposed Conditions Building Counts				Existing Conditions Building Count[1]	Buildings Removed (Benefit)
	Building Count Flow Depth 0.25' < h ≤ 0.5'	Building Count Flow Depth 0.5'< h ≤ 1'	Building Count Flow Depth 1' < h	Total Building Count		
Proposed Conditions (25-year Regional Basins)						
25-yr 24-hr	177	16	4	**197**	**388**	**191**
100-yr 24-hr	436	157	19	**612**	**967**	**355**
100-yr 6-hr	595	90	12	**697**	**1227**	**530**
Hyp. July 2015	572	144	13	**729**	**1073**	**344**
Proposed Conditions (100-year Regional Basins)						
25-yr 24-hr	177	16	4	**197**	**388**	**191**
100-yr 24-hr	572	137	11	**720**	**967**	**247**
100-yr 6-hr	406	82	11	**499**	**1227**	**728**
Hyp. July 2015	571	114	13	**698**	**1073**	**375**
Proposed Conditions (Johnson Lane Wash Dam)						
25-yr 24-hr	279	49	17	**345**	**388**	**43**
100-yr 24-hr	588	194	64	**846**	**967**	**121**
100-yr 6-hr	743	292	81	**1116**	**1227**	**111**
Hyp. July 2015	727	219	56	**1002**	**1073**	**71**

[1]*from Table 6-2*

Table 8-6. Summary of flood damage estimates and potential benefit for the three proposed conditions scenarios

Recurrence Interval	Economic Loss				Estimated Economic Benefit
	Residential $ millions	Total Property $ millions	Business Interruptions $ millions	Total Economic Loss $ millions	$ millions
Proposed Conditions (25-year Regional Basins)					
25-yr 24-hr	2.00	2.08	0.42	2.50	0.14
100-yr 24-hr	3.61	3.81	0.42	4.24	0.67
100-yr 6-hr	4.13	4.37	0.42	4.79	0.76
Hyp. July 2015	3.33	3.49	0.42	3.91	0.59
				Total Benefit:	2.16
Proposed Conditions (100-year Regional Basins)					
25-yr 24-hr	2.02	2.10	0.42	2.52	0.12
100-yr 24-hr	3.65	3.85	0.42	4.27	0.64
100-yr 6-hr	4.11	4.34	0.42	4.76	0.79
Hyp. July 2015	3.42	3.59	0.42	4.01	0.49
				Total Benefit:	2.04
Proposed Conditions (Johnson Lane Wash Dam)					
25-yr 24-hr	1.91	1.95	0.42	2.38	0.26
100-yr 24-hr	3.31	3.44	0.42	3.86	1.05
100-yr 6-hr	3.79	3.94	0.42	4.36	1.19
Hyp. July 2015	3.24	3.36	0.42	3.78	0.72
				Total Benefit:	3.22

Table 8-7. Property buy-out analysis results

Douglas County Assessed Value (476 impacted parcels)	Zillow Market Value (215 buildings)	Johnson Lane Wash Dam Construction Cost Estimate
$42,094,965	$90,565,000	$4,900,000

9 ADMP SUMMARY AND RECOMMENDATIONS

9.1 PROJECT PHASING

The regional alternatives presented in this report can be constructed in phases as funding is acquired or becomes available. It is recommended that each basin system be constructed as its own project, however funding availability may limit how many structures can be constructed simultaneously. For example, the Hot Springs-Buckbrush System is designed to function utilizing all basin, channel, and pipe elements, however, constructing the sediment basins alone could provide some interim benefit. That said, constructing the basin systems piecemeal should be done cautiously so as not to cause adverse flooding conditions due to point-source releases of stormwater from a basin outlet. The total benefits, costs and effectiveness evaluated by system are summarized in Table 9-2).

9.1.1 Combinations with On-site Alternatives

Based on the results summarized in Table 9-2, the Pine Nut North and South Systems may benefit in being combined with the individual lot detention alternative analysis presented in Section 7.2.3. The onsite detention will increase the efficiency of the total alternative by capturing the onsite rainfall that is downstream of the regional alternative. It is recommended that an individual lot detention plan for the Pine Nut North and South Systems area be implemented in addition to the offsite structures or in lieu of the Chowbuck Wash Basin (which was not as effective when reviewing the detailed results).

9.1.2 Initial Prioritization and Design Level

The analysis results suggest that the 25-year design level for the Pine Nut North, Pine Nut South, and Unnamed Wash A systems provide the majority of the benefit of the 100-year systems. This suggests that these 25-year systems should be strongly considered for final design and construction. That said, the 100-year designs for any of the systems would provide the most potential benefit and should be considered.

It is recommended that Douglas County and the residents of the community work collaboratively to validate/refine the study results and in future implementation of any of the elements presented in this Area Drainage Master Plan.

Table 9-1. Initial prioritization and design level matrix

Priority	System	Design Level
1	Pine Nut North	25-Year
2	Johnson Lane Wash Dam	PMF
3	Hot Springs-Buckbrush	100-Year
4	Pine Nut South	25-Year
5	Unnamed Wash A	25-Year

Table 9-2. Relative benefit comparison by system

Regional Alternative System	Percent Buildings Removed[1] (potential inundation)	Percent Buildings Removed[1] (potential inundation)	Buildings in System Area	Construction Cost (100-Year Basins)	Annual Maintenance Cost (100-Year Basins)	Construction Cost (25-Year Basins)	Annual Maintenance Cost (25-Year Basins)	Cumulative Loss Estimate Reduction (HAZUS)	Percent Flow Reduction at Key Locations (100-Year Basins)	Percent Flow Reduction at Key Locations (25-Year Basins)
	100-Year, 6-Hour 100-Year Basins	25-Year, 24-Hour 25-Year Basins							100-Year, 6-Hour	25-Year, 24-Hour
Unnamed Wash A	23%	63%	19	$330,000	$6,600	$240,000	$4,200	$14,000	92%	90%
Hot Springs-Buckbrush	32%	40%	1,527	$8,020,000	$161,600	$6,150,000	$107,000	$1,080,000	91%	89%
Pine Nut North	24%	20%	1,181	$1,380,000	$27,900	$880,000	$15,300	$840,000	71%	0%
Pine Nut South	2%	14%	153	$1,430,000	$28,700	$1,130,000	$19,600	$109,000	28%	50%
Johnson Lane Wash Dam (PMF)										
Johnson Lane Wash Dam	44%	-	679	$4,900,000	$13,900	$4,900,000	$13,900	$3,220,000	82%	62%
TOTALS	**69%**	**68%**	**3,532[2]**	**$16,700,000**	**$239,000**	**13,800,000**	**$160,000**	**$5,300,000**	**-**	**-**

1. Flow depth > 0.25 feet
2. Total number of buildings within the study area is less than the sum of column 4 values due to minor overlapping between Regional Alternative Systems

9.2 Potential Funding Sources

There are numerous potential grant sources that could be explored by the Johnson Lane community and Douglas County to partially or fully fund the alternatives presented in this study. Some examples of these grants are shown in Table 9-3.

Table 9-3. Potential grant funding sources

Grant	Funding Agency	Qualifications	Description
Pre-Disaster Mitigation (PDM)	FEMA	FEMA approved Hazard Mitigation Plan[1].	Awards planning and project grants and provides opportunities for raising public awareness about reducing future losses before disaster strikes.
Flood Mitigation Assistance (FMA)	FEMA	Structures insured under the NFIP. Projects submitted for consideration must be consistent with the goals and objectives identified in the agency's Hazard Mitigation Plan.	Awards projects and planning grants that reduce or eliminate long-term risk of flood damage to structures insured under the NFIP.
Hazard Mitigation Grant Program (GMGP)	FEMA	Presidential Major Disaster Declaration. 25% cost share from applicant.	Funding for projects listed in the agency Hazard Mitigation Plan.
[1] *https://www.douglascountynv.gov/DocumentCenter/View/2255*			

9.3 Next Steps

This report is presented to the Carson Water Subconservancy District, Douglas County, and the impacted property owners with the goal that each entity will work collaboratively to reduce the flooding and sedimentation hazards within the Johnson Lane community. The following next steps are offered to provide a framework for utilizing the information from the ADMP:

- Douglas County officials and Johnson Lane residents review this report.
- Douglas County officials and Johnson Lane residents establish a workgroup or committee to discuss and prioritize the alternatives and develop a Capital Improvement Plan (CIP) to implement construction of the highest priority alternatives (with Table 9-1 as a guide). This plan should include final design and construction of recommended projects.
- Douglas County officials investigate and explore potential funding options to implement the CIP.
- Douglas County recommends specific projects to proceed to final design.
- Recommended projects go to construction.

It should be noted this does not represent a binding legal agreement on any partners, but does provide a plan for executing the recommended alternative for each system.

9.3.1 Flood Warning Network

The primary benefit and overarching purpose of a flood warning network is to provide advanced awareness to emergency response agencies of rapidly developing flood threats which may impact major roadways, residential areas and critical public facilities. This ADMP recommends regional flood mitigation structures as discussed in Section 8. For many of these structures, flood warning instrumentation would be a critical component of their operation and maintenance. For example, it is recommended that the Johnson Lane Wash Dam structure include instrumentation to measure stage, outflow, and rainfall.

In many cases, a flood warning network results in helping people to stay clear of flooded washes and roadways and provide general awareness that would potentially result in action and/or preparations which contribute to decreasing risks to life and property. Additional benefits to the public agency operating a flood warning system include:

- Maintain an accessible historical database of rainfall and streamflow data and information useful for hydrologic and hydraulic model calibration.
- Improve floodplain management through better understanding of local hydrology and meteorology.
- Collect and share real-time and near-real-time hydro-meteorological data and information with the public.
- Fulfil an advisory role to emergency responders before, during and after flood emergencies.
- Participate in flood preparedness activities.

The residents of the Johnson Lane community currently benefit from a reverse 911 system that is operated by the Douglas County Office of Emergency Management (OEM)[4]. OEM receives real-time information from National Weather Service forecasts and warnings as well as on-the-ground reports from Douglas County staff and disseminates emergency warning messages to residents as needed. The current system would benefit from a supplemental flood warning network with gages and instrumentation specific to the watersheds impacting the Johnson Lane community.

9.4 JLADMP Limitations

While the results are based on detailed topography, hydrology, and hydraulic modeling, they represent the current existing conditions as of the date of the LiDAR mapping (May 2017). Because of the unique sediment characteristics of the watershed, the topography and distribution of flow can be very dynamic (i.e., small culverts or drainage channels can quickly fill with sediment causing water to change course from what it was previously). Therefore, during final design of any of the alternatives, a detailed assessment of upstream flow distribution should be undertaken.

[4] http://www.douglascountynv.gov/1182/Reverse-9-1-1